



Lyndon B. Johnson Space Center Houston Texas 77058

ORBITER SUBSYSTEM

HARDWARE/SOFTWARE INTERACTION ANALYSIS

VOLUME VIII: FORWARD REACTION CONTROL SYSTEM

1	(NASA-TM-80960) ORBITER SUBSYSTEM	N80-18089
	HARDWARE/SOFTWARE INTERACTION ANALYSIS.	,
ł	VOLUME 8: AFT REACTION CONTROL SYSTEM, PART	_
	2 (NASA) 136 P HC A07/NF A01 CSCL 09B	
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January 1980



PREFACE

The Orbiter subsystem hardware/software interaction analysis examines software interaction with hardware failure modes. Each failure mode identified in subsystem FMEA (failure mode and effects analysis) is examined for interaction with software. The analysis is based upon key questions which identify potential issues. These potential issues are to be resolved by providing rationale for retention or identifying and implementing changes to eliminate the issue.

The figure on the following page illustrates the relationship of the hardware/software interaction analysis to the verification process which leads to the statement of flight readiness. As shown, the analysis is a supporting item which is a portion of the data base utilized by the FRAT's (flight readiness assessment teams) and the associated SEAM (Systems Engineering Assessment Meeting) teams in planning and controlling the verification process. The overall issue of hardware/software interface compatibility is addressed by the verification process itself. The analysis scope is limited to examination of single failure modes, as identified in the FMEA, and the interaction of these failure modes with the software as reflected by the software requirements.

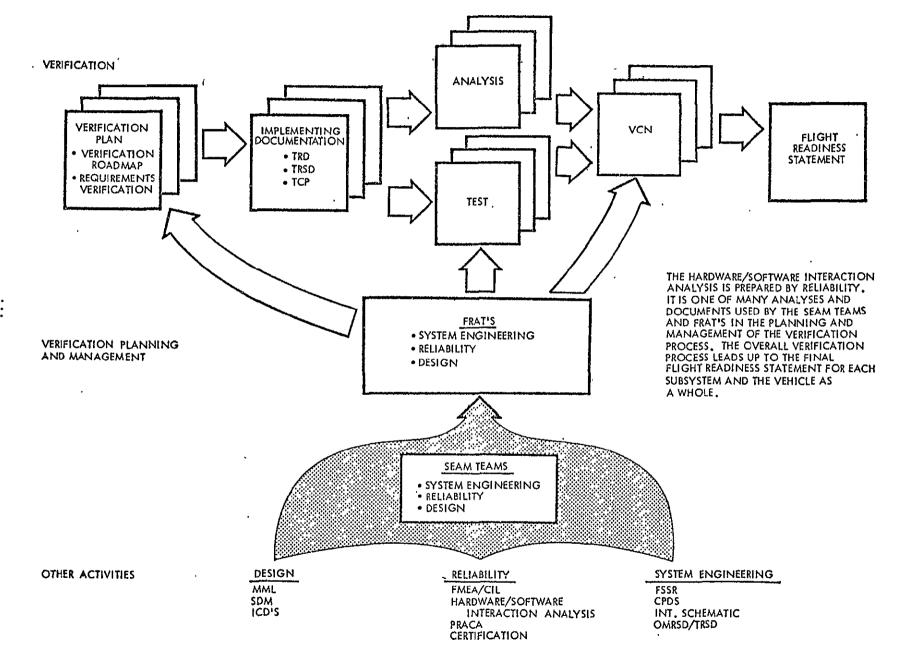
The hardware/software interaction analysis is performed on a preliminary basis by the JSC Reliability Division. Results are then coordinated with JSC engineering and Rockwell/Space Systems Group engineering and reliability to obtain inputs and approval signatures. The approval sheet for the Forward Reaction Control System are presented below. The Rockwell signatures represent their review of the open issues and risks, if any, performed against the summarization of the analysis. Section 5.0 presents the analysis summary which groups the failure modes by similar retention rationale and is a convenience in identifying groups of failure modes in which the analysis is similar. The reviews with Rockwell did not cover each checklist. The minutes presented in the appendix document the nature and depth of the Rockwell analysis review.

This analysis verified that no open issues remain.

Approved:

Joseph H. Levine

Chief, Reliability Division



Forward Reaction Control System SUBSYSTEM

FMEA # SD75-SH-0016A

ANALYSIS DATE June 25, 1979

APPROVED:

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Rockwell Engineering FRAT Sponsor

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- 1.0 <u>INTRODUCTION</u>. This report documents the results of the analysis of the hardware/software interaction analysis for the Forward Reaction Control System. This analysis examines the interaction between hardware failure modes and software in order to identify associated issues/risks. These issues/risks are resolved through changes to software requirements to remove them, or surfaced to project/program management with appropriate retention rationale.
- 2.0 <u>SCOPE</u>. All Orbiter subsystems and interfacing program elements which interact with the Orbiter computer flight software are analyzed. The analysis for each subsystem or interfacing element is presented in a separate volume of this report (see section 3.1).

The analysis examines failure modes identified in the subsystem/element FMEA (failure mode and effects analysis). Potential interaction with software is examined through evaluation of the software requirements, not detailed implementation. The analysis is restricted to flight software requirements only, and excludes utility/checkout software. The BFS (backup flight system) software is considered only as necessary, and only as it differs from the primary; the basic thrust of the analysis is keyed to the primary system.

The analysis is based upon the hardware design and software requirements as they existed as of the date of the analysis. Future updates will be published as necessary to incorporate changes to either the hardware or software.

3.0 APPLICABLE DOCUMENTS.

3.1 HARDWARE/SOFTWARE INTERACTION ANALYSIS REPORT VOLUMES. The hard-ware/software interaction analysis results are reported on a subsystem basis, each in a separate volume. The separate volumes which make up this report are as follows:

<u>Volume</u>	Subsystem
I III III VV VI VIII VIII XX XI XIII XIII XIV XV XV	Purge, Vent, and Drain Payload Deployment and Retention Payload Bay Doors Main Propulsion Data Processing Subsystem Hydraulics Auxiliary Power Unit Reaction Control Electrical Power Orbital Maneuvering Environmental Control and Life Support Integrated Avionics Electrical Power Distribution & Control GNC (Guidance, Navigation & Control) Support Displays & Controls Communications & Tracking
XVII	Instrumentation

- 3.2 REFERENCE DOCUMENTS. The primary documents used in performing the analysis included the following:
- a. SD75-SH-0016A, "Failure Mode Effects Analysis, Forward Reaction Control Subsystem," Dec 18, 1978.
- b. JSC 11174, "OV-102 Space Shuttle Systems Handbook," September 22, 1977.
- c. SD76-SH-0026A, "Functional Subsystem Software Requirements, Sequence Requirements," March, 1978.
- d. SD76-SH-0020, "Functional Subsystem Software Requirements, Displays and Controls," February 1, 1978.
- e. SD76-SH-0027D, "Functional Subsystem Software Requirements, Systems Management," October 16, 1978.
- f. MG038103, "Backup Flight System Management/Special Processes and Sequencing Program Requirements Document," December 20, 1978.
- g. SD75-SH-0010E, "Functional Subsystem Software Requirements, Redundancy Management," June 1, 1979.

4.0 DESCRIPTION.

- 4.1 GROUND RULES. The hardware software analysis is performed according to the following ground rules:
- a. The hardware/software analysis will be limited to investigating the software interaction with the failure modes of the hardware as delineated in the subsystem FMEA's.
- b. Software interaction will be limited to involvement of software of the onboard computers.
- c. Only failure modes of hardware with software interfaces (software monitoring and/or software control) are analyzed.
- d. The software detection must be considered with respect to each phase of the mission [prelaunch (OPS 1 only), ascent, onorbit, and entry].
- 4.2 ANALYSIS CHECKLIST. The basic tool for the analysis is the checklist (figure 4-1). A separate checklist is used for each failure mode analyzed. Note that the "FMEA Number" in the heading refers to the FMEA document number, not the page number on which the failure mode is treated.

The checklist consists of three sections: Body, change/retention rationale summary, and explanation/comments. Each of these sections is dicussed below.

SUBSYSTEM FMEA NUMBER _____ FAILURE MODE DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ٦. ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD ***YFS** USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF 2. IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. NO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE *YES PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. NO INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 5. ACCEPTANCE RATIONALE BELOW 1. _ NO H/S ISSUES 3. NO SOFTWARE DETECTION 2. HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT 6. RECOMMENDED CHANGES BELOW FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: Figure 4-1. Hardware/Software Analysis Checklist.

.HARDWARE/SOFTWARE ANALYSIS CHECKLIST

The questions in the checklist body are answered using the following guidelines:

- a. Question 1. Will the information provided to the onboard software and the processing of that information cause annunciation of the failure and/or initiation of a corrective action in response to this failure mode?
- b. Question 1a. Answer question 1a. if the answer to question 1 is "no." Information available to the software could be in the form of (1) sensor data used by onboard software but not for automatic fault detection (data used in software routines or fault detection available through callup or dedicated displays); (2) system and/or subsystem performance parameters; or (3) measurements which are downlisted. Answer "yes" if such information could be used to annunciate the failure condition or initiate responsive action. In explanation comments, specifically identify the information available for software detection.
- c. Question 2. If all of the following questions are answered "no," check the "no" block and explain the difference in the explanation/comments section:
- (1) Are the master measurements listed under "Failure Detectability In-flight" on the FMEA (1) used by the onboard software in detecting time critical failures (if routed to GPC), or (2) used by the onboard software in annunciating non-time critical failures via callup displays, or (3) downlisted for non-time critical failures?
- (2) Are other measurements, dedicated displays, crew detection, and system/subsystem parameters available or able to detect this failure mode?
- (3) If "failure detectability in-flight" specifies only software action, does the software actually initiate the corrective action as called out in the "corrective action" portion of the FMEA?
- d. Question 3. The question considers only the cases wherein the software determines a failure.
- e. Question 3a. Answer question 3a if the answer to 3 is "no." If the answer to 3a is "yes," call out the possible corrective action in the explanation/comments section.
- f. Question 4. The question is considered for both the detected and the undetected failure. The overstress or inducement of another failure may be acceptable action. Overstress by software is improper commands, sequencing, or timing resulting in action exceeding hardware design requirements or exposing hardware to excessive environments.
- g. Question 5. The question is considered for both the detected and the undetected failure. Limit adverse effects to effects directly resulting from software commands or subsequent actions resulting from erroneous inputs as a result of the failure.
- h. Question 6. The hardware/software may change the method of detection and/or correction after the first or the second failure; consider this in answering the question. Determine if the software will be able to use the redundance of the hardware. If the hardware/software interaction following the particular failure mode changes the criticality, in comparison to the FMEA, check the box provided in the summary section of the checklist.

- i. Question 7. If crew action is not required to respond to the failure, check the "N/A" block. Cues which provide inputs to the crew include but are not limited to cathode-ray tube annunciation, caution and warning, visual cues, audible cues, callup and dedicated displays, subsystem status data, panel meters, etc.
- (1) Question 8.A. Consider that the failure occurs while the vehicle is being flown using the primary system. What will happen if the BFS must be engaged subsequent to the failure? Will the fact that the failure has occurred prevent the BFS from operating properly, under any conditions? A "no" answer is a potential issue (requiring explanation) only if the BFS can normally tolerate the failure (when it occurs during BFS operation).
- (2) Question 8.B. Consider that the failure occurs while the vehicle is under BFS control. A "no" answer is an issue (requiring explanation) only if the BFS response differs from that for the primary system.
- 4.2.2 <u>Change/Retention Rationale Summary.</u> Each failure is assigned to one of six possible groups, based upon the answers obtained in the checklist body. Boxes are provided to indicate the category assigned. Figure 4-2 presents the criteria for group assignment.

A box is also provided to indicate that changes are required to the FMEA. The FMEA evaluation of in-flight detectability is sometimes inaccurate and requires change. In addition, other errors (e.g., incorrect criticality assignment or incorrect evaluation of redundancy screens) are occasionally noted during the analysis and are documented here.

A space is provided to detail acceptance rationale, change recommendations, or suggested FMEA changes. This space may also be used to provide a short general comment to expand the retention rationale grouping.

- 4.2.3 <u>Explanation/Comments</u>. Each question answered by checking a box identified with an asterisk is discussed in this section. The circumstances for checking a box not identified with an asterisk are discussed, and the rationale for not making such a change is presented, if applicable. This section may also be used to explain, expand, or qualify answers. Each discussion is identified with the corresponding question number.
- 4.3 ANALYSIS SUMMARY. The analysis results are summarized on the basis of retention rationale grouping and recommended changes/retention rationale. Figure 4-3 depicts the form utilized for this purpose. A particular retention rationale definition, acceptance rationale statement, or recommended change is listed in the left column, with the applicable failure modes listed on the right. The issue/risk is briefly described with acceptance rationale or software requirements change recommendation. The summary provides a basic overview of the total analysis results.
- 5.0 ANALYSIS SUMMARY SHEETS. The analysis results are summarized on the following sheets. The failure modes have been grouped by issue/retention rationale (or change), affording an overview of the results for the entire subsystem.

CHANGE/RETENTION RATIONALE

- 1. NO * CHECKED NO HARDWARE/SOFTWARE ISSUES ARE APPARENT FROM THE ANALYSIS. SYSTEM IS FAIL OPERATIONAL/FAIL SAFE WITH RESPECT TO THIS FAILURE MODE UNDER CURRENT DESIGN.
- 2. ONLY * CHECKED ON QUESTION 6 NO HARDWARE/SOFTWARE ISSUES ARE APPARENT FROM THE ANALYSIS. RISK HAS BEEN ACCEPTED VIA HARDWARE CIL.
- 3. ONLY * (YES) CHECKED ON QUESTION 1a NO SOFTWARE DETECTION IS PROVIDED. FAILURE EFFECT IS NOT TIME CRITICAL. FAILURE MAY BE DETECTED BY OTHER MEANS OR FUNCTION IS NOT MISSION/SAFETY CRITICAL.
- 4. * CHECKED ON QUESTION 3a * ON 1a MAY OR MAY NOT BE CHECKED SOFTWARE DOES NOT TAKE CORRECTIVE ACTION FOR FAILURE. FAILURE EFFECT IS NOT TIME CRITICAL. CORRECTIVE ACTION MAY BE INITIATED BY CREW. PLANNED CHECKOUT ACTIVITIES WILL DETECT FAILURE. SYSTEM IS FAIL OPERATIONAL/FAIL SAFE WITHOUT SOFTWARE DETECTION AND CORRECTION.
- 5. STANDARD RETENTION RATIONALE DOES NOT APPLY. SPECIFIC RETENTION RATIONALE IS SUMMARIZED FOR THIS FAILURE.
- 6. ISSUES IDENTIFIED AND CHANGES ARE DESIRABLE. SPECIFIC CHANGES ARE SUMMARIZED.

NOTE: DO NOT CONSIDER ANSWER TO QUESTION 2 IN DETERMINATION OF CHANGE/RETENTION RATIONALE SUMMARY CODE. CONSIDER RESPONSES TO BOTH QUESTION 2 AND 6 IN DETERMINING WHETHER AN FMEA CHANGE IS REQUIRED.

SUBSYSTEM	FMEA _	
ANALYSIS RESULT	ITEM/FAILURE MODE	
Figure 4-3. Hardware/Software Analysis Summary		

ITEM/FAILURE MODE

HARDWARE ACCEPTS RISK

ANALYSIS RESULT

Helium Storage Tank - Rupture (03-2F-101010-1) Helium Feedline - External Leakage (03-2F-101013-1) Quick Fill Disconnect, He - Fails Open, Cap Leaks (03-2F-101070-1) Test Quick Disconnect, Propellant - Ext. Leakage/Flight (03-2F-101090-1) Propellant Line Flex Assy. - External Leakage (03-2F-102106-1) Feedline and Fittings - External Leakage (03-2F-102108-1) AC Motor Operated Valve (Tank) - Fails Closed (03-2F-102120-1) Quick Disconnect - External Leakage (03-2F-102150-1) DC Solenoid Operated Valve - Fails Closed - Premature Operation (03-2F-102170-1) Tank Assembly and Propellant Acquisition Device - Small Crack - External Leakage (03-2F-111110-2) Tank Assembly and Propellant Acquisition Device - Restricted Flow (03-2F-111110-3) Tank Assembly and Propellant Acquisition Device - Loss of Gas in Propellant Acquisition Device (03-2F-111110-4) Flex Line and Fittings - External Leakage (03-2F-121308-1) Thrust Chamber - Burn Through (03-2F-121312-1) Nozzle Extension - Burn-Through (03-2F-121313-1) Vernier Thruster - Erratic Operation (03-2F-131310-3) Vernier Thruster - Burn-Through (03-2F-131310-4) Helium Pressure Regulator - Fails Closed (03-2F-101030-2) Tank Assembly and Propellant Acquisition Device - Large Rupture (03-2F-111110-1) Purge Quick Disconnect, Propellant - External Leakage During Flight (03-2F-101080-1) Helium Quad Check Valve - Fails Closed (03-2F-101095-2) Vernier Thruster - Loss of Output (03-2F-131310-1)

SUBSYSTEM Forward Reaction Control	HARDWARE/SUFTWARE ANALYSIS SUMMARY FMEA SD75-SH-0016A
ANALYSIS RESULT	ITEM/FAILURE MODE
NO HARDWARE/SOFTWARE ISSUES	D.C. Solenoid Valve - Fails to Close (03-2F-101020-3) D.C. Solenoid Valve - Fails Closed (03-2F-101020-4) Helium Pressure Regulator - Fails Open (03-2F-101030-1) Relief Valve - External Leakage Overboard (03-2F-101060-1) Relief Valve - Burst Disc Ruptures (03-2F-101060-2) Relief Valve - Fails to Burst (03-2F-101060-3) (Relief Valve - Opens Low (03-2F-101060-4) Relief Valve - Fails to Open (03-2F-101060-5) Helium Quad Check Valve - Fails Open (03-2F-101095-1) Injector Plate - Mixture (03-2F-121311-1)
9	

ANALYSIS RESULT	ITEM/FAILURE MODE
UT OF SCOPE - GROUND ONLY .	Manual Valve - Fails Closed or Open (03-2F-101050-1)
	Manual Valve - Internal Leakage (03-2F-101050-2)
	Quick Fill Disconnect, He Fails Closed/Ground OPS (03-2F-101070-2)
	Purge Quick Disconnect, Propellant - Fails Closed/Ground OPS. (03-2F-101080-2)
	Test Quick Disconnect, Propellant - Fails Closed/Ground Ops (03-2F-101090-2)
	Quick Disconnect - Fails Closed/Ground Ops. (03-2F-102150-2)

6.0 ANALYSIS CHECKLIST SHEETS

Following are the analysis checklist sheets for each failure mode evaluated.

.HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101010-1 SUBSYSTEM Fwd Reaction Control FMEA NUMBER SD75-SH-0016A ITEM <u>Helium Storage Tank</u> FAILURE MODE Rupture DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY YES X NO ٦. ANNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD la. *YES 110 USE TO DETECT THE FAILURE? 2. ARE THE AUSWERS TO QUESTIONS I AND IA CONSISTENT WITH THE FMEA EVALUATION OF ON* X IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. YES INO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE 3a. *YES NO X PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR ſΧ 4. *YES 1110 INDUCE ANOTHER FAILURE? CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT 5. *YES NO | X OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 X *1 ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. N/A YESX HO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSHER TO EITHER 1 OR 3 IS YES: 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? 1*110 B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? YES 1×N0 *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. \[NO H/S ISSUES 3. NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 6. RECOMMENDED CHANGES BELOW 2. A HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT FMEA CHANGE RECOMMENDED **EXPLANATION/COMMENTS:** GAX will give a class 2 alert upon sensing an out-of-tolerance condition. (<500 psi) Gross leak detection will give a class 2 alert.

Backup flight system same as primary.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM	:FWO - REACTION CO	NTROL	FMEA NO	03-2F	-10101	C-1	ĸĒV:1	2/18/7
	: PRESSURIZATION		A SORT:					
	:MC292-0082-0031/-						HWU:	
			MISSION	S: HE	'VE X			
•QUANTITY			PHASE(S					
	:ONE REQ! D PER EAC	·						
	:PROPELLANT TANK		AFTER F				NATIVIN	C
•	· PROFELEANT TANK						N. 71	-
• TANKERS DA	T		EDUNDANCY	2011 EEV			-	U-N/A
	TECTABLE IN FLIGHT				· · · -	TO EFF		
	NDICATION V42	P-IIICC	•				ECOMUS	
.1113C							UCUMEN	TS:
•					MJ070	-0001-	ClB	
.GROUND TUR	RNAKGUND?	YES			S072-	5H-01 <i>0</i>	3-2	
.SAME AS FL	_I GHT				VS 70-	421001		
•								
•								
•								
•	PREPARED BY:			441	PROVEC	ьY:		
•	DS S	.1	TAGGART		ΰES			
•	REL		R DIEHL					
•	N-2		17 10 11:10		,,,,,,			
•								
* 175M* T**	,							
.1TEM: TANK								
	STORAGE, FILAMENT V	YUUNÐ •						
.FUNCTION:								

- TO STORE HELIUM AT A MAX WORKING PRESSURE OF 4000 PS1 FOR PRESSURIZATION OF THE FWD RCS MODULE PROPELLANT SUPPLY SYSTEM. TANK CONSISTS OF A DOUBLE MELT TI LINER WITH DUPONT 49 FISER AND EPDXY RESIN FONDING OVER WRAP.
- .FAILURE MCDE: RUPTURE, EXFERNAL LEAK (S)
- RUPTURE LARGE CKACK WHICH PROPUGATES AROUND TANK IMMEDIATELY.
 LEAKAGE FRACTURE WHICH DOES NOT PROPOGATE TO RUPTURE.
- .CAUSE(S):
- VIPRATION, STRESS CORRUSION, TEMP. RISE, FATIGUE, INADVERTANT OVER-PRESSURIZATION (GROUND OPS).
- .EFFECT(S): ON (A)SUBSYSTEM (b)INTERFACES (C)MISSION (b)CREW/VEHICLE:
- (a) Loss of pressurization to fuel or oxidizer.
 (6) EXPLOSIVE
- EXPANSION OF HELIUM WITHIN RCS MODULE. (C) POTENTIAL LOSS OF MISSION-ABORT DECISION DEPENDANT ON EXTENT OF DAMAGE. (C) POTENTIAL LOSS OF CREW/VEHICLE.
- .CCRRECTING ACTION:
- NONE AVAILABLE EXCEPT POSSIBLE RESCUE IF VEHICLE STILL INTACT.
 REMARKS/HAZARDS:
- HAZARD OF SHRAPNEL PROPAGATION, HOWEVER, UTILIZATION OF FILAMENT WOUND TANK MINIMIZES OR ELIMINATES THIS HAZARD. ADDITIONAL HAZARD OF MODULE OVER PRESSURIZATION STILL EXISTS. NO REDUNDANCY PROVIDED FOR THIS ITEM - REFERENCE HAZARD 1YXX-0302-02.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

REV:11/09/78 SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -101010-1 .ASSEMBLY :PRESSURIZATION CRIT. FUNC: ABORT: CRIT-HDw: .P/N RI :4C282-0C82-0031/-0032 1 .P/N VENDOR:BLD-999040 VF X FF SF S.M MISSIONS: HF QUANTITY PL X LO X OO X DO X LS - 2 PHASE(S): :ONE REQ'D PER EACH :PROPELLANT TANK C-4/4 REDUNDANCY SCREEN: 4-4/ A A\N-8 APPROVAD BY LINASAY .PREPARED BY: APPROVED BY: \$ **5** M .DES J TAGGART .REL REL R DIEHL

.ITEM: TANK

. HELIUM STORAGE, FILAMENT WOUND.

.FUNCTION:

- TO STORE HELIUM AT A MAX WORKING PRESSURE OF 4000 PSI FOR PRESSURIZATION OF THE FWD RCS MODULE PROPELLANT SUPPLY SYSTEM. TANK CONSISTS OF A DOUBLE HELT TI LINER WITH DUPONT 49 FIBER AND EPOXY RESIN BONDING BYER HRAP.
- .FAILURE MODE: RUPTURE, EXTERMAL LEAK (S)
- RUPTURE LARGE CRACK WHICH PROPOGATES AROUND TANK IMMEDIATELY. LEAKAGE FRACTURE WHICH DOES NOT PROPOGATE TO RUPTURE.

-CAUSE(S):

- VIBRATION, STRESS CORROSION, TEMP. RISE, FATIGUE, INADVERTENT OVER-PRESSURIZATION (GROUND OPS).
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF PRESSURIZATION TO FUEL OR OXIDIZER. (B) EXPLOSIVE EXPANSION OF HELIUM WITHIN RCS MODULE. (C) POTENTIAL LCSS OF MISSION-ABORT DECISION DEPENDANT ON EXTENT OF DAMAGE. (D) POTENTIAL LOSS OF CREW/VEHICLE.
- -DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY:
 - (A) FILAMENT WOUND TANKS ARE DESIGNED TO LEAK BEFORE RUPTURE WHICH LIMITS FAILURE PROPAGATION DUE TO SCHRAPNEL. INCREASED STRAIN CAPABILITY IS PROVIDED BY THE COMPRESSIVE LOAD ON AN UNPRESSURIZED LINER. THE FACTOR OF SAFETY IS 1.5 X MAX WORKING PRESSURE OF 4000 PSIG. DUAL SEALS ARE PROVIDED AT TANK FLANGE. (B) TANKS ARE SUBJECTED TO PROOF PRESSURE (1.1x WORKING PRESSURE) DURING ACCEPTANCE TESTING. TESTS INCLUDE 1000 PRESSURE CYCLES EQUAL TO 4 TIMES LIFE PEQUIREMENT: 90 DAY CREEP TEST AT MAX WORKING PRESSURE PLUS RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS FOR 48 MIN IN EACH AXIS. (C) IN PROCESS -INSPECTION INCLUDES RADIO GRAPHIC INSPECTION OF HELDS & FLUORESCENT PENETRATION INSPECTION FOR SURFACE FLAHS. TURNAROUND CYCLE FOR EVIDENCE OF RUPTURE. AUDIT CONDUCTED 3/9/78 VERIFIED SUPPLIER RECEIVING INSPECTION CONTROLS RAW MATERIAL AND PURCHASED COMPONENTS AND IN-HOUSE INSPECTION CONTROLS CORROSION PROTECTIVE PROVISIONS, TEST HANDLING STORAGE ENVIRONHENTS, MEASUREMENT STANDARDS, TEST EQUIPMENT, NDE TESTING, PARTS PROTECTION, MFG PROCESSES AND FINISHES. CHEMICAL ETCHING, X-RAY AND PROOF TEST OF LINER AND MECHANICAL PROPOERTIES AFTER HEAT TREAT ALSO VERIFIED BY INSPECTION. (D) NO HISTORY AVAILABLE. TANK IS BEING DEVELOPED FOR SHUTTLE PROGRAM.

-HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101013-1 SUBSYSTEM Fwd Reaction Control FMEA NUMBER SD75-SH-0016A FAILURE MODE ___External Leakage ITEM Helium Feedline DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY YES X NO ANNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD la. USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF YES X **** 2. IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE NO 3. (EITHER BY COMMANDING MARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS *YES NO 3a. FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR *YES Olfi 4. INDUCE ANOTHER FAILURE? NO CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT 5. OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW 6. ACTION AND HARDWARE/SOFTWARE OPERATION)? HOTE CHANGE TO FMEA CRITICALITY. N/A YESIX NO IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? X | *110 X *NO B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? . *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION: RATIONALE SUMMARY 3. NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELCK 1. NO H/S ISSUES RECOMMENDED CHANGES BELOW *4. DETECTION DURING CHECKOUT 2. X HARDWARE ACCEPTS RISK FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: GAX will give a class 2 alert upon sensing an out-of-tolerance condition. (<500 psi) Gross leak detection will give a class 2 alert. Backup flight system same as primary. 8.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM .ASSEMPLY .P/N R1	:FWD - REACTION CONT :PRESSURIZATION HELI :VC70-421701	(ROL (UM -	FMEA NO C: ABORT:	3-2F -		CRIT.	REV:11 FUNC: HWJ:	Ţ
•P/N VENDO			MISSIGNS:	LC		-		
• YTLTMAUP•			PHASE(S):					
• NORSCIE!	ONE SET PER PROPELL	ANT						
-	*	-13.4.1	AFTER FIR			113 14	12, 2, 5, 1, 4,	G
•		RE	DUNDANCY SO	_		A B-	~îv ∕ A	C-N/A
.FAILURE D	ETECTABLE IN FLIGHT?.					O EFF		
.HFLIUM TA	NK PRESSURE DRO P AT	OFF-NO	FINAL RATE	;	IMMEDI	Alt		
.V42P-11100	C;1112C;1113C; 11140	•			KEFER	NCE U	JCUMEN [*]	TS:
.GROUND TU	RNAROUND?	.YES	•		MJ073-	-0001-0	J15	
.SAME AS FI	LIGHT INSTRUMEN TATIO)N			5072-5	Sh-0101	3-2	
•	•				VS70-4	+21001		
•								
•								
•	PREPARED BY:				OVED E	5 Y :		
•	DES		EGELIN		ÚÉ\$			 -
•	REL	R	DIEHL		スヒレ			
•							•	
TTCU+ UCI	IUM FEED LINE AND							
• FLUID F								
.FUNCTION:	1111/05*							
	ICE FEED LINE FROM HE	≓LEUM T/	ANKS TO HE	LTHM				
	ION/PRESSURATION SYST							
TANKS:								
.FAILURE M	ODE: EXTERNAL LEAKAG	3E	(s)					
•		•						•
.CAUSE(S):								
	CAL SHOCK, VIBRATION, ITTING SEAL FAILURE.	/FATIGU	E, IMPROPE	R INST	ALLAT :	IUN IW	:Lu).	
	: ON (A) SUBSYSTEM (B)							
	S OF HELlum SUPPLY IF		•					
	D VALVE). (B) POTEN							
	OSS LEAK. (C,D) POTE							
	/CREW/VEHICLE IF GRUS	SS LEAK	OCCURS DU	RING C	KITICA	L MAN	EUVになる	•
.CORRECTIN	G ACTION:							

- INITIATE ABORT. CHECK VALVES MAINTAIN PROPELLANT TANK RESIDUAL GAS PRESSURE TO ALLOW POTENTIAL PLOW DOWN MODE UTILIZATION. REMARKS/HAZARUS:
- NO REDUNDANCY PROVIDED FOR LINES. IF LEAK RATE IS EXCESSIVE PRESSURE BUILD-UP IN MODULE MAY RESULT IN HAZARD. SEE HAZARD IYXX-0302-L2.

OF POOR QUALITY

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

FMEA NO 03-2F -101013-1 SUBSYSTEM : FNO - REACTION CONTROL REV: 11/09/7 CRIT. FUNC: 1 ABCRT: .ASSEMBLY :PRESSURIZATION HELIUM -HOW: 1 CR IT • .P/N RI :V070-421701 0F VF X FF S M -P/N VENDOR: MISSIGNS: HF PL X LO X CO X CO X LS X PHASE(S): -QUANTITY :ONE SET PER PROPELLANT REDUNDANCY SCREEN: A \ M-A B-N/4 C-N/4 APPROMED BY .PREPARED 8Y:. APPROVED BY & E. E. Same SSH A SIEGELIN DES -DES ο 5Ø **TOUR** REL R DIEHL REL PPROVED WITH CHANGES See Section 13.0 .ITEM: HELIUM FEED LINE AND FLUID FITTINGS. .FUNCTION: TO PROVIDE FEED LINE FROM HELIUM TANKS TO HELIUM REGULATION/PRESSURATION SYSTEM AND TO PROPELLANT TANKS. **{S}** .FAILURE HODE: EXTERNAL LEAKAGE .CAUSE(S): MECHANICAL SHOCK, VIBRATION/FATIGUE, IMPROPER INSTALLATION (WELD). FLUID FITTING SEAL FAILURE. .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE: (A) LOSS OF HELIUM SUPPLY IF NOT ISOLATABLE. (IE. IF UPSTPEAM OF (8) POTENTIAL OVERPRESSURIZATION OF FCPHARD MODULE SOLENOID VALVE). (C.O) POTENTIAL MODULE DAMAGE RESULTING IN LOSS OF FROM GROSS LEAK. MISSION/CREM/VEHICLE IF GROSS LEAK OCCURS DURING CRITICAL MANEUVERS. .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C) INSPECTION (D) FAILURE HISTORY; (4) FACTOR OF SAFETY OF 4.0 WILL MINIMIZE FAILURE POTENTIAL. FLUID WELD CONSTRUCTION REDUCES JOINTS AND POSSIBLE FITTINGS HAVE DUAL SEALS. FASTENING CLAMPS AND TUBE BEND DESIGN ALLOWS DEGREE OF LEAK PATHS. (B) POST INSTALLATION TEST AND MOVEMENT WHICH HELPS PREVENTING LEAKS. OPERATIONAL CHECKDUTS WILL VERIFY SYSTEM INTEGRITY. ALL LINES SUBJECTED TO 1.25 PROOF TEST. (C) IN PROCESS INSPECTION INCLUDES NOT & LEAK CHECKS DURING INSTALLATION. TURNAROUND INSPECTION INCLUDES MONITORING FUNCTIONAL TESTS DURING PRESSURIZATION CYCLE FOR EVIDENCE OF LEAKS. WHERE ACCESSABLE VISUALLY INSPECT FOR DAMAGE. HARDWARE INSPECTION IN ACCORDANCE WITH PLANNING ROMTS APPROVED BY NASA. MIMOR FAILURE HISTORY-CORROSION AND FAB PROBLEMS REPORTED DURING APOLLO PROGRAM AND CORRECTED. HARDWARE INSPECTION IN ACCORDANCE WITH APPLICABLE TMO/TPC REQUIREMENT. WITH PLANMING RONTS APPROVED BY NASA. (D) MINOR FAILURE HISTORY-CORROSION AND FAB PROBLEMS REPORTED DURING APOLLO PROGRAM AND CORRECTED.

.HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101020-3 SUBSYSTEM __Fwd Reaction Control FMEA NUMBER SD75-SH-0016A FAILURE MODE Fails to Close ITEM ____ D. C. Solenoid Valve - Helium DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY 1. X ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES 910 USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA.EVALUATION OF 2. **10 IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. YES X NO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE 3a. X PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. *YES OM I INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT *YES NO X OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? MOTE CHANGE TO FMEA CRITICALITY. 7. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YESX 110 TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: . 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? YES B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? X +NO YES *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. X NO H/S ISSUES 3. \(\simega \) NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 2. HARDWARE ACCEPTS RISK. 4. DETECTION DURING CHECKOUT 6. RECOMMENDED CHANGES BELOW In-Flight Detectability X FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS:

Switch scan will detect failure in OPS-2 only and only on demand. May not be used on STS-1.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -101020-3 REV:63/06/7. .ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: .P/N PI :MC284-C419-0011/-0C12 CRIT. HWB: .P/N VENDOR: 73835 MISSIONS: HF VF X FF C.E PHASE(S): PL X LO X UO X DO X LS .QUANTITY :4 :TWO REGID PER PRESSURANT NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE: : FEED ASSEMBLY REDUNDANCY SCREEN: A-PASS E-PASS C-PASS .FAILUPE DETECTABLE IN FLIGHT?. YES TIME TO EFFECT: .HELIUM TANK PRESS, V42P 1110,1112,1113,1114, SECONDS .AND PRESS LINE: V42P1115, 1116 AND POSITION IND. KEFERENCE DOCUMENTS: .112CX,1122X,1124X,1126X VE70-008245 .GROUND TURNAROUND?.....YES MJ070-0001-016 .SAME AS FLIGHT INSTR. SU72-SH-0103-2 VS70-421001 PREPARED BY: APPROVED BY: R BURKHART DES LE S REL R DIEHL KEL

.ITEM: VALVE, D.C. SOLENOID

- GPERATED, HIGH PRESSURE. HE (2600-4000 PSIA) SOLENGID ACTUATED, 51-STABLE, (1/2") (LV 101/102/103/104).
- .FUNCTION:
- THESE VALVES ARE UTILIZED TO CONTROL HELIUM PRESSURIZATION OF THE RCS MODULE. IN THE OPEN POSITION A FLOW PATH IS PROVIDED FROM THE HELIUM SUPPLY TANK(S) TO THE REGULATUK(S). TWO PARALLEL PATHS ARE PROVIDED FOR FUEL AND OXIDIZER. ONE PATH IS NORMALLY OPEN PER TANK. THE VALVE IS CLOSED AND PARALLEL VALVE OPENED SUBSEQUENT TO A DOWN STREAM FAILURE.
- .FAILURE MODE: FAILS TO CLOSE (F)
- . WHEN COMMANDED TO ISOLATE DOWNSTREAM FAILURES
- .CAUSE(S):
- CUNTAMINATION, VIBRATION, LOSS OF ELECTRICAL INPUT, IMPROPER OPENING ACTUATION, PIECE PART FAILURE.
- .effect(s): ON (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE:
- . (A,C,D) NO EFFECT, VALVE IS FUNCTIONED (CLOSED) ONLY SUBSEQUENT TO A
- 2ND ORDER FAILURE. (B) NO EFFECT, DDES NOT INTERFACE WITH UTHER SUBSYSTEMS.
- .CORRECTING ACTION:
- . NONE -
- . REMARKS/HAZARDS:
- . NONE.



		FTWARE ANALYSIS CHECK	
	SUBSYSTEM Fwd Reaction Control	FMEA RUMBER	
	ITEM D. C. Solenoid Valve - Helium	FAILURE MODE	Fails Closed
1:	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	MODE (i.e., AUTOMATICALI	YES NO 🗌
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION USE TO DETECT THE FAILURE?	I THAT THE FLIGHT SOFTWAR	E COULD *YES NO
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSIST IN-FLIGHT DETECTABILITY?	TENT WITH THE FMEA EVALUA	ATION OF YES X *NO
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATION TO NEGATION OR IMPROVED THE RESERVE TO THE PROPERTY OF THE PR	TE THE EFFECTS OF THE FAI LEMENTING ALTERNATE PROGR	ILURE YES NO X
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOF FAILURE MODE (EITHER BY COMMANDING HARDWARE A PROGRAM LOGIC)?	FTWARE TO COMPENSATE FOR ACTION OR IMPLEMENTING AL	THIS *YES NO X
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOI INDUCE ANOTHER FAILURE?	FTWARE OVERSTRESS THE HAP	ROWARE OR *YES NO X
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SO OTHER FUNCTIONS?	OFTWARE LOGIC, ADVERSELY	AFFECT *YES NO X
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE : ACTION AND HARDWARE/SOFTWARE OPERATION)? NO	SHUTTLE TOLERATE (CONSIDE TE CHANGE TO FMEA CRITICA	R CREW *0 *1 2 X ALITY.
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS TO SIGNAL THE NEED FOR INTERVENTION AND THE	S FAILURE MODE, ARE CUES REQUIRED CORRECTIVE ACTIO	PROVIDED N/A YESX NO H
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	,	·
	A AND THE DEC DE ENGACED ACTED ACCHIODENCES		YES X *NO
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?		, 20 til 110 til
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF		YES X *NO
*EXF			
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CANATION REQUIRED (SEE BELOW)		YES X *NO
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY	F CREW/VEHICLE?	
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO 5. ACCEPTANCE RATIONALE BELOW
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO 5. ACCEPTANCE RATIONALE BELOW
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO 5. ACCEPTANCE RATIONALE BELOW
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO 5. ACCEPTANCE RATIONALE BELOW
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO 5. ACCEPTANCE RATIONALE BELOW
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	TWARE DETECTION ION DURING CHECKOUT	YES X *NO 5. ACCEPTANCE RATIONALE BELOW 6. RECOMMENDED CHANGES BELOW
CHAN	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	F CREW/VEHICLE?	YES X *NO 5. ACCEPTANCE RATIONALE BELOW 6. RECOMMENDED CHANGES BELOW
CHAN 1. [2. [B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF TANATION REQUIRED (SEE BELOW) IGE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOF	TWARE DETECTION ION DURING CHECKOUT	YES X *NO 5. ACCEPTANCE RATIONALE BELOW 6. RECOMMENDED CHANGES BELOW

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUSSYSTEM	:FWD - REACTION	CONTROL	FMEA NO	03-2F	-101020	j - 4	KEV:13	2/じとノブに
ASSEMBLY	:PRESSURIZATION		ABORT:			.TIXO	FUNC:	1 હ
P/N'RI	:MC284-0419-001	1/-0012				CRIT.	HWD:	2
PIN VENDOR	R: 73835		MISSION.	S: HF	ν	FF O	F S'	1
YTITKAUC,	: 4		PHASEIS): PL	X LO X	00 X 0	U X LS	2
•	:TWO REQ'D PER	PRESSURANT	NUMBER	of succ	ESS PA	THS REM	AINING	,
•	: FEED ASSEMBLY		AFTER F	IRST FA	ILURE:			1
•		R	EDUNDANCY	SCREEN	: A-P	4SS 5-	PASS	C-FAII
FAILURE DE	ETECTABLE IN FLI	GHT?. YES			TIME	Từ EFFE	CT:	
	ANK PRESSURE			TION	MINUT	±5		
	(,1122x,1124X,					ENCE DO	CUMENT	rs:
•					VL70-0	008249		
.GROUND TUR	RNAROUND?	YES			MJ070	-0t01+0	15	
SAME AS FI	LIGHT INSTR.				S072-	SH-0103	-2	
•					V\$70-	421001		
•								
•								
•	PREPARED BY	′ :		APF	ROVEO	BY:		
•	DES		URKHART		DES			
•	REL	•	R DIEHL		KEL			
-					• • • • •			
-								

.ITEM: VALVE, D.C. SOLENOID CHE/IUM - PRESSURIZATION SYSTEM)

- . OPERATED, HIGH PRESSURE. HE (36GC-4000 PSIA) SOLENGID ACTUATED, EI-STARLE, (1/2") (LV 101/102/103/104). FUNCTION:
- THESE VALVES ARE UTILIZED TO CONTROL HELIUM PRESSURIZATION OF THE RCS MUDULE. IN THE OPEN POSITION A FLOW PATH IS PROVIDED FROM THE HELIUM SUPPLY TANK(S) TO THE REGULATOR(S). TWO PARALLEL PATHS ARE MEDITED FOR FUEL AND OXIDIZER. ONE PATH IS NORMALLY OPEN PEK TANK. THE VALVE IS CLOSED AND PARALLEL VALVE OPENED SUBSEQUENT TO A JOHN STREAM FAILURE.

.FAILURE MODE: FAILS CLOSED (F)

.CAUSE(S):

- . VIERATION, CONTAMINATION CONTINUOUS INADVERTENT CLOSING SIGNAL DUE TO SHORT CIRCUIT, PIECE PART FAILURE.
- .EFFECT(S): UN (A)SUBSYSTEM (B)INTERFACES (C)MISSION (B)CREW/VEHICLL:
- . (A) LOSS OF REDUNDANT PRESSURIZATION PATH. (8,0) NO EFFECT. (C)
- . ABURT DECISION DEPENDENT ON MISSION PHASE AND BLUWDOWN CAPABILITY. .CERRECTING ACTION:
- . IF CAUSED BY VIBRATION, THE VALVE MAY BE CAPABLE OF OPENING WITH A NEW COMMAND OR, SWITCH TO PARALLEL REGULATION PATH COMMAND PAKALLEL ISOLATION VALVE OPEN.
- .REMARKS/HAZARDS:
- POTENTIAL HAZARD IN ABORT SITUATION. SEE CONSOLIDATED CONTRULS FMEA NUMBER 73835 FMEA 1.

ORIGINAL PAGE IS OF POOR QUALITY

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM : FWO - REACTION CONTROL FMEA NO 03-2F -101020-4 REV: 12/08/ .ASSEMBLY *PRESSURIZATION ABORT: CRIT. FUNC: .P/N RI :MC284-0419-0011/-0012 CRIT. HOH : 2 •P/N VENDOR:73835 MISSIONS: OF SM HF VF X FF . QUANTITY PHASE(S): PL X LO X CO X DO X LS :TWO REQID PER PRESSURANT :FEED ASSEMBLY REDUNDANCY SCREEN: A-PASS B-PASS C-FA: APPROVED, BY -PREPARED BY: APPROVED BY (NASA): .DES R BURKHART DES SSM AL THORES 7415775 .REL C. E. Jana R DIEHL REL REÀ Markthail APPROVED WITH CHANGES See Section 13.0 .ITEM: VALVE, O.C. SOLENOID OPERATED, HIGH PRESSURE. HE (3600-4000 PSIA) SCLENOID ACTUATED, BI-STABLE, (1/2") (LV 101/102/103/104). .FUNCTION: THESE VALVES ARE UTILIZED TO CONTROL HELIUM PRESSURIZATION OF THE RCS MODULE. IN THE OPEN POSITION A FLOW PATH IS PROVIDED FROM THE HELIUM SUPPLY TANK(S) TO THE REGULATOR(S). THO PARALLEL PATHS ARE PROVIDED FOR FUEL AND OXIDIZER - ONE PATH IS NORMALLY OPEN PER TANK. THE VALVE IS CLOSED AND PARALLEL VALVE OPENED SUBSEQUENT TO A DOWN STREAM FAILURE. .FAILURE MODE: FAILS CLOSED (F) .CAUSE(S): VIBRATION, CONTAMINATION CONTINUOUS INADVERTENT CLOSING SIGNAL DUE TO SHORT CIRCUIT, PIECE PART FAILURE. .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSIGN (D)CREW/VEHICLE: (A) LOSS OF REDUNDANT PRESSURIZATION PATH. (B,D) NO EFFECT. $\{C\}$ ABORT DECISION DEPENDENT ON MISSION PHASE AND BLOWDOWN CAPABILITY. -DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY: (A) SERIES CONTROL CIRCUITRY PROVIDED TO MINIMIZE FAILURE MODE, 100 MICRON FILTER IS PROVIDED. MEDIA HAS BEEN FILTERED TO 25 MICRON PRIOR TO ENTERING TANK. SPECIAL EMPHASAS PLACED ON THE DESIGN AND LAYOUT OF SOLENOID WIRING TO PRECLUDE SHORTS. (B) QUAL TEST INCLUDES 48 MINUTES PER AXIS OF RANDOM VIBRATION AT ANTICAPTED MISSION LEVELS AND LIFE TESTING CONSISTING OF 2200 OPERATING CYCLES. ITEM IS USED DURING SYSTEM EVALUATION AT WHITE SANDS TESTING. (C) TURNAROUND INSPECTION INCLUDES MONITURING TESTS TO VERIFY ELECTRICAL POWER TO SOLENOID VALVE FOR EVIDENCE OF SHORT CIRCUIT, SUPPLIER AUDIT CONDUCTED 8-31-77 VERIFIED SUPPLIER INSPECTION EXCERCISED CONTROL OF PARTS ID, PARTS PROTECTION, MFG PROCESSES, CONTAMINATION CONTROL, AND CORROSION PROTECTION VERIFICATION. (D) THERE IS NO FAILURE HISTORY FOR THIS SPECIFIC DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101030-1 SUBSYSTEM Fwd. Reaction Control SD75-SH-0016A FMEA NUMBER FAILURE MODE Fails Open ITEM Heljum Pressure Regulator DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY NO X 1. YES ANNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD X *YES N0 la. USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FREA EVALUATION OF X *#0 IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. YES N0 (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS *YES NO 3a. FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 110 4. X *YES INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT IX I OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 | *1 | 2 | X | 6. ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A X YES NO 7. TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: 8. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 5. ACCEPTANCE RATIONALE BELOW 1. [X] NO H/S ISSUES 3. \(\) NO SOFTWARE DETECTION 4. DETECTION DURING CHECKOUT 6. RECOMMENDED CHANGES BELOW 2. HARDWARE ACCEPTS RISK FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: 1. Detection of this failure mode is not desired as these are redundant series regulators.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

| 17 > 2°C ·

SUS SYSTEM	:FWD - REACTIO	ON CONTROL	FMEA NO	03-2F -	-101036-1	ધ ક	FA: CO	/13/7.
.ASSEMBLY	: PRES SUKIZATIO)N	ABORT:		Cf	KII. F	UNC:	
.P/N PI	:MC284-G418				Ct	II.	н%0:	3
.P/N VENDOR	R:74339001		MISSION:	S: HF	VF X F	- UF	- SM	İ
• @CANTITY	: 4		PHASE(S)): PL	LO X 00) X DO	X LS	•
•	:TWO REQUIRED	PER	NUMBER (OF SUCCE	SS PATHS	RÉMA	INING	:
•	:PRESSURANT PA	ATH (AFTER F	IRST FAI	LURE:			1
•		P	EDUNDANCY	SCREEN:	A-P ASS	S B-N	I/A	C-FAS!
.FAILURE DE	ETECTABLE IN FL	LIGHT?. N/A			TIME TO	£FF±0	.T:	
.STANDBY UN	NIT				SECONUS			
•					REFEREN	DE DUC	UMENT	\$ =
•					VS70-42	LCC1		
.GROUND TUR	RNAROUND?	YES			MJ070-0	001-01	.E	
*GPOUND CHE	ECKOUT TEST	PORTS			S072-SH	-0103-	·2	
•								
•								
•								
•	PREPARED A	ēΥ:		APPH	Re davos	:		
•	DES	J.	TAGGART		DES _			
•	REL		R DIEHL		REL _			
•								

.ITEM: REGULATOR, PRESS, HE.

- SERIES REQUNCANT. SET AT UNEQUAL OUTLET PRESSURES PRIMARY SET LUWER THAN SECONDARY (PR 101/102/103/104).
- .FUNCTION:
- . TO REGULATE STORED HELIUM PRESSURE FROM 4000 PSIG MAX TO ULLAGE PRESSURE OF 245 (+ GR −3) PSIG FOR PURPUSE OF PROPELLANT FLCD TO THRUSTERS. TWO PARALLEL PATHS WITH TWO SERIES REGS ARE PROVIDED FUR EACH PROPELLANT TANK.
- .FAILURE MODE: FAILS OPEN (F)
- . OR LEAKS INTERNALLY.
- .CAUSE(S):
- . CONTAMINATION, VIBRATION, PIECE PART STRUCTURAL FAILURE-FLEXURES, SELLOWS, POPPET ASSY.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHILLE:
- . (a) LOSS OF UNE REGULATOR ELEMENT IN ONE PATH (PRIMARY) AND RISE IN
- PROPELLANT PEED PRESSURE TO SECONDARY REGULATOR ELEMENT PRESSURE SETTING. (3,C,D) NONE.
- .CORRECTING ACTION:
- . NONE REQUIRED SERIES REGULATOR ELEMENT WILL AUTOMATICALLY TAKE OVER FUNCTION.
- .REMARKS/HAZARDS:
- . SEE FAIRCHILD FMEA # RR74339-12.

OF POOR PAGE

-HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101030-2 SUBSYSTEM Fwd Reaction Control FMEA NUMBER SD75-SH-0016A ITEM Helium Pressure Regulator FAILURE MODE Fails Closed YES X NO DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ٦. AMNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES ОŊ la. USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA.EVALUATION OF 2. IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE YES NO 3. (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS χ *YES NO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT *YES I NO X OTHER FUNCTIONS? *0 | *1X HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW 6. ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YESX NO 7. TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSHER TO EITHER 1 OR 3 IS YES: 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? YES סאַ∗וּע וּ B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? . X *NO *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY I. NO H/S ISSUES . . 3. NO SOFTWARE DETECTION ACCEPTANCE RATIONALE BELCH 6. RECOMMENDED CHANGES BELOW 4. DETECTION DURING CHECKOUT 2. X HARDWARE ACCEPTS RISK FMEA should be changed from "NA" to "yes" for in-flight detectability via V42P1115C and 1116C. X FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: V42P1115C, 1116C, will sense the pressure drop initiating a class 2 alarm from GAX. Failure is "hardware detectable" by V42P1115C and V42P1116C pressure drop. 2. 6. Upon regulator failure the redundant parallel "leg" can be utilized.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORDITER 102

SUBSYSTEM : FWO - REACTION CONTROL .ASSEMBLY : PRESSURIZATION	FMEA NO 03- ABURT:	2F -101030-2 REV:11/13/70 CRIT. FUNC: IR
.P/N R1 :MC284-0419		CRII. FWU: Z
.P/N VENDOR: 74339001	MISSIONS:	HE VEX FE UF SM
. OUANTITY :4 . TWO REQUIRED PER		PL LO X GO X DO X LS UCCESS PATHS REMAINING
. :PRESSURANT PATH		
• TINGOUNANI I ATII		EEN: A-PASS E-PASS C-PASS
.FAILURE DETECTABLE IN FLIGHT? . NA		TIME TO EFFECT:
STANDBY REDUNDANCY		MINUTES
•		REFERENCE DOCUMENTS:
• GROUND TURNAROUND?YE	¢	V570-421001 MJ670-6001-015
GROUND CHECKOUT TEST PORTS	3	SD72-SH-0103-2
• TOWER		00/2 011 0200 2
••		•
•		
. PREPARED BY:		APPROVED BY:
DES J	. TAGGART R DIEHL	BES
• KEL	K DIEGE	NEL
•		
.1TEM: REGULATUR, PRESS, HE,	-	
. SERIES REDUNDANT. SET AT UNEQU	AL GUTLET PRESS	SURES - PRIMARY SET LOWER
THAN SECONDARY (PR 101/102/103/	104).	
.FUNCTION:	CONTRACTOR AND O	SETE MAN TO LIFEDS
. TO REGULATE STORED HELIUM PRESS PRESSURE OF 245 (+ OR -3) PSIG	IOKE EKOM 4000 F	DENDERHANT FIED TO
THRUSTERS. TWO PARALLEL PATHS		
EACH PROPELLANT TANK.		
.FAILURE MODE: FAILS CLOSED	(F)	
. (LOW PRESSURE)		
.CAUSE(S):	T DE DILOT (CDC)	AND THE SEASONS AND SECTIONS OF THE SEASONS
. CONTAMINATION (PARTIAL BLUCKAGE PART FAILURE, VIBRATION.	UP PILOT SCREE	EW) PROVER WOTZIONE PIECE
.EFFECT(S): ON (A) SUBSYSTEM (B) INT	FREACES (C)MISS	SION (D)CREW/VanICLE:
. (A) LOSS OF ONE REGULATOR PATH.		
. ADDITIONAL FAILURE MAY CAUSE LO	SS OF PRESSURIZ	ZATION AND SUBSEQUENT
VEHICLE LOSS. (D) NONE. (E)		
FAILURE OCCUR BEFORE ET SEPARAT		
SEPARATION AND LOSS OF CREW/VER	AICEE MAGED KEZE	JLI.
.CCRRECTING ACTION: . CLOSE HIGH PRESSURE ISOLATION V	VALVE IN SEEECT	ED PATH AND OPEN HIGH
PRESSURE ISOLATION VALVE IN PAR	WEAR THE COL	LD LATH AND OF ALL HIZOLI
	CALLEL PATH.	
.REMARKS/HAZARDS:	KALLEL PATH.	
 REMARKS/HAZARDS: POTENTIAL ABORT BECAUSE ONE ADD OF PRESSURIZATION AND SUBSEQUENT 	OITIONAL FAILURE	

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -101030-2 PEV:11/13/76 .ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 12 ₌P/N RI :MC284-0418 CRIT. HDw: .P/N VENDOR:74339001 MISSIONS: HF VF X FF OF SM PHASE(S): QUANTITY :4 PL LO X OO X DO X LS :TWO REQUIRED PER *PRESSURANT PATH

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

.PREPARED BY: -DES J. TAGGART -REL R DIEHL

APPRONED BY: DES AL IMMU 2115178 REL / C. I. James

APPROVED BY INASAI: SSM W. J. January RELIGI LOW South

APPROVED WITH CHANGES See Section 13.0

.ITEM: REGULATOR, PRESS, HE,

SERIES REDUNDANT. SET AT UNEQUAL DUTLET PRESSURES - PRIMARY SET LOWER THAN SECONDARY (PR 101/102/103/104).

-FUNCTION:

- TO REGULATE STORED HELIUM PRESSURE FROM 4000 PSIG MAX TO ULLAGE PRESSURE OF 245 (+ OR -3) PSIG FOR PURPOSE OF PROPELLANT FEED TO THRUSTERS. TWO PARALLEL PATHS WITH TWO SERIES PEGS ARE PROVIDED FOR EACH PROPELLANT TANK.
- .FAILURE MODE: FAILS CLOSED (F)
- (LOW PRESSURE)
- .CAUSE(S):
- CONTAMINATION (PARTIAL BLOCKAGE OF PILOT SCREEN) FROZEN MOISTURE PIECE PART FAILURE, VIBRATION.
- «EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF ONE REGULATOR PATH. (B,C) POTENTIAL ABORT BECAUSE ONE ADDITIONAL FAILURE MAY CAUSE LOSS OF PRESSURIZATION AND SUBSEQUENT VEHICLE LOSS. (D) NONE.

DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY: (A) EXPERIENCE FROM PREVIOUS REGULATOR DESIGN TO BE APPLIED TO PRECLUDE PIECE PART FAILURE AND SELF GENERATED CONTAMINATION. ALSO, 25 MICRON INTREGAL INLET FILTER PROVIDED TO MINIMIZE CONTAMINANTS. (B) QUAL TESTING INCLUDES 28 HOUR SAND AND DUST TEST, 48 MINUTES PER AXIS OF RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS AND LIFE CYCLE TESTS OF 50.000 CYCLES FOR THE MAIN STAGE AND 100.000 CYCLES FOR PILOT STAGE. (C) TURNARBUND INSPECTION INCLUDES MONITORING TESTS TO VERITY FUNCTIONAL OPERATION IS WITHIN SPECIFIED LIMITS. SUPPLIER AUDIT CONDUCTED VERIFIES WITHIN SPECIFIED LIMITS. SUPPLIER AUDIT CONDUCTED VERIFIES SUPPLIER CONTAMINATION CONTROL. AND STORAGE ENVIRONMENT. (D) NEW DESIGN FOR SHUTTLE APPLICATION. NO FAILURE HISTORY DATA AVAILABLE FOR THIS DESIGN.

	HARDWARE/SOFTWARE SUBSYSTEM _ Fwd. Reaction Control	E ANALYSIS CHECKLIST FMEA HUMBER	T 03-2F-101050-1 SD75-SH-0016A			
	ITEM <u>Manual Valve</u>	FAILURE MODE Fails				
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES X HO				
]a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT TUSE TO DETECT THE FAILURE?	ILD *YES NO				
2.	ARE THE ANSWERS TO OUESTIONS 1 AND 1a CONSISTENT WI IN-FLIGHT DETECTABILITY?	OF YES X *110				
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE (EITHER BY CONTANDING HARDWARE ACTION OR IMPLEMENTI	OGIC)?				
3a.						
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE INDUCE ANOTHER FAILURE?	E OR *YES NO X				
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE OTHER FUNCTIONS?	T *YES 110 X				
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHAN	W *0 X *1 2 2				
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YESX NO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?					
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES: A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	vec [V] tuo :				
B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?			YES X +1:0			
*EXPLANATIO: REQUIRED (SEE BELOW)						
	GE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOFTWARE D	FTECTION 5 F	ACCEPTANCE RATIONALE BELOW			
	☐ HARDWARE ACCEPTS RISK 4. ☐ DETECTION DUR		RECOMMENDED CHARGES BELOW			
, []						
FMEA CHANGE RECOMMENDED						
EXPLANATION/COMMENTS:						
1.	1. If valve is cracked open V42P1115A, 1116A would alarm.					
6.	6. There are no success paths remaining after first failure.					

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORFITER 102

	:FWO - REACTION (:PRESSURIZATION	CONTROL	FMEA NO 0: ABORT:	3-2F -10105	C-1 RE CRIT. FU	V:C1/U	4/7
	:MC284-0480-0001				CRIT. H		3.
.P/N VENDOR	R:5760015, 576001	5	MISSIONS:	HF VF X	FF OF	SM	
			PHASE(S):	PL LŪ X	00 X D0	X LS	
•	ONE REQ D PER TA	4 NK	NUMBER OF	SUCCESS PA	THS REMAI	NING	
•	•			ST FAILURE:			C
•		RED	UNDANCY S	CREEN: A-P	ASS E-N/	'A C-	PAS
.FAILURE DI	ETECTABLE IN FLIG	HT7. YES		TIME	TO EFFECT	[:	
• PPOPELLAN	ETECTABLE IN FLIG T TANK PRESSURE V	42P-1210 , 11	15,1116,1	310 SECON	DS FO MIN	≀⊎T⊯S	
•							
•					-0001-018		
	RNAROUND?	• • • • YES		SD72-	SH-0103-2	<u>?</u>	
SAME AS F	LIGHT			vs70-	421001		
•							
•							
•	PREPARED BY:			APPROVED	6 V •		
•	DES	R. GON	17 AT G 7	25C			
•	REL	K # GO!	DIEHL	KEL			
•	KEL	1	OILIIL	17.22			
•							
.TTEM: VAL	VE, MANUAL-OPERATE	n.		•			
	ITION SELECTOR VA		TRUCTURAL	INTERLOCK)	(MV 101/	102).	
.FUNCTION:					•		
	IDE ISOLATION OF	PROPELLANT	TANK(S) F	ROM PRESSUR	E CYCLES	WHILE	
PERFORM	ING GROUND C/O AN	D/OR SERVIC	ING OF PR	ESSURIZATIO	IN SYSTEM.	•	
.FAILURE M	ODE: FAILS CLOSE	D OR OPEN	(_)				
	RAL FAILURE.						
.CAUSE(S):							
. SEVERE	MECHANICAL SHOCK	OR VIBRATIO	N CAUSING	DETENT MOV	PEMENT ON	A	
DEFICIE	NT VALVE LOSS OF	INTERLOCK B	Y FRACTUR	RE OF ORIVE	FINGLR OF	₹	
KULKER,	COKKOZION, CONIA	MINAIIUN: 1	LWAKO REK O	S⊆•			
	: ON (A) SUBSYSTEM						
	LOSS OF FUNCTION	(IN ABILITY	' 10 PERFO	IRM SYS C/D.	, (C) L	4UYCH	
_	(D) NO EFFECT.						
.CORRECTIN							
	AILABLE.						
.R EMARKS/H							
 NO HAZA 	RDS IDENTIFIED.						

ORIGINAL PAGE IS OF POOR QUALITY

	HARDWARE/SOFTWARE		· · · · · · · · · · · · · · · · · · ·			
	SUBSYSTEM Fwd. Reaction Control	FMEA NUMBER	SD75-SH-0016A			
	ITEM Manual Valve	FAILURE MODE <u>Inte</u>	ernai Leakage			
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	i.e., AUTOMATICALLY	YES X NO			
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT TUSE TO DETECT THE FAILURE?	HE FLIGHT SOFTWARE C	OULD *YES NO N			
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITIN-FLIGHT DETECTABILITY?	TH THE FMEA EVALUATIO	OH OF YES X *NO			
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE E (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTED					
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TFAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION (PROGRAM LOGIC)?					
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE (INDUCE ANOTHER FAILURE?	OVERSTRESS THE HARDWA	ARE OR *YES NO X			
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE OTHER FUNCTIONS?	LOGIC, ADVERSELY AFF	FECT *YES NO X			
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANG	TOLERATE (CONSIDER O SE TO FMEA CRITICALIT	CREW *0 X *1 2 2			
7.	. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YESX NO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?					
8.	8. IF THE ANSWER TO EITHER 1 OR 3 IS YES:					
A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?			YES 🗓 +110			
B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? YES X *NO						
*EXPLANATION REQUIRED (SEE BELOW)						
CHAN	GE/RETENTION RATIONALE SUMMARY					
		ETECTION 5.	ACCEPTANCE RATIONALE BELOW			
	☐ HARDWARE ACCEPTS RISK 4. ☐ DETECTION DUR		RECOMMENDED CHANGES BELOW			
•						
			•			
_	FMEA CHANGE RECOMMENDED					
EXPLANATION/COMMENTS:						
If you is smaked ones WASBITIES 1116A						
1. If valve is cracked open V42P1115A, 1116A would alarm.						
6. There are no success paths remaining after first failure.						

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - CRBITER 102

	:FWD - REACTION CONTR			-2 REV:01/	(4/7.
	: PRESSURIZATION	ABORT:		CRIT. FUNC:	_
	:MC284-0480-0001/-000			CRIS. HWD:	3
	:5760015, 5760016	MISSIONS	: HF VF X	FF OF SM	
.OUANTITY			: PL LG X		
•	:ONE REQ D PER TANK		F SUCCESS PAT		
•	:		RST FAILURE:		Ð
•			SCREEN: A-PA	SS B-N/A C	-PAS:
	TECTABLE IN FLIGHT?.			O EFFECT:	
•PROPELLANT	TANK PRESSURE V42P-1	1210,1115,1116,			
•				NCE OUCUMENTS	:
•			MJ070-	C001-018	
	NAROUND?	.YES		H-0103-2	
.SAME AS FL	IGHT		VS70-4	21001	
•					
•					
•					
•	PREPARED BY:		APPROVED B	Υ:	
•	DES	R. GONZALEZ	DES		
•	REL	R DIEHL	REL		
•					
•					
.ITEM: VALV	E, MANUAL-OPERATED.				
	TION SELECTOR VALVE	(WITH STRUCTURA	L INTERLOCK)	(MV 101/102).	
.FUNCTION:)				
	IDE ISOLATION OF PROPE				
	NG GROUND C/O AND/OR		RESSURIZATION	SYSTEM.	
.FAILURE MC	DE: EXCESSIVE INTER	VAL (_	_)		
. LEAKAGE.	•				
.CAUSE(S):					
. SEVERE !	MECHANICAL SHOCK OR VI	IBRATION CAUSIN	IG DETENT MOVE	MENT ON A	
DEFICIEN	IT VALVE LOSS OF INTER	RLOCK BY FRACTI	RE OF UPIVE P	INGER OR	
RUCKER,	CORKOSION, CONTAMINAT	FION, IMPROPER	USE.		
	ON (A) SUBSYSTEM (E):				
. (A,E) LO	DSS OF FUNCTION (IN A	BILITY TO PERFO	RM SYS C/G).	(U) LAUNCH	
. DFLAY.	(D) NO EFFECT.				
.CCRRECTING	ACTION:				
. NONE AVA	AILABLE.				
-REMARKS/HA	AZARDS:				
. NO HAZAF	RDS IDENTIFIED.				

	· HARDWARE/SOFTWAR					
	SUBSYSTEM <u>Fwd Reaction Control</u> ITEM Relief Valve	FMEA NUMBER		-SH-0		
	TIEN NOTICE VALVE	FAILURE MODE E	xternal L	eakag	e uverb	oard
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	(i.e., AUTOMATICALLY		YES	Х ио	
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT USE TO DETECT THE FAILURE?	THE FLIGHT SOFTWARE	COULD	*YES	016	
2.	ARE THE ANSWERS TO QUESTIONS I AND la CONSISTENT WI IN-FLIGHT DETECTABILITY?	TH THE FMEA EVALUAT	ION OF	YES	X *#0	
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENT)			YES	☐ NO	X
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION PROGRAM LOGIC)?	TO COMPENSATE FOR TH OR IMPLEMENTING ALTH	HIS ERHATE	*YES	□ №	X
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE INDUCE ANOTHER FAILURE?	OVERSTRESS THE HARDI	WARE OR	*YES	□ 40	X
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE OTHER FUNCTIONS?	LOGIC, ADVERSELY AF	FFECT	*YES	☐ NO	X
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHAR	: TOLERATE (CONSIDER GE TO FMEA CRITICALI	CREW	*0 [*1	2 X
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILUTO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRE		ROVIDED (1/A [YESX ii	0 🗌
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:					
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?		•	YES	X *#0	
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/	VEHICLE?		YES	(Х]*мо	
*EXP	LANATION REQUIRED (SEE BELOW)	•				
CHAN	GE/RETENTION RATIONALE SUMMARY				-, :	
`	NO H/S ISSUES . 3. □ NO SOFTWARE D	ETECTION 5.	. ACCEPT	ANCE R	ATIONALE	BELOW
_	☐ HARDWARE ACCEPTS RISK 4. ☐ DETECTION DUF		. RECOMM			
	•	•				-
•		•			•	•
						•
	• • •				• •	
	•	<i>:</i>				
	•	FMEA CHANGE R	RECOMMENDED			•
- FY	PLANATION/COMMENTS:					
<u></u> v	- CHIMIT TOTAL CONTROLLED .	-				

1. Leakage of helium will cause a class 2 alarm. Gross leak detection should occur first.

	FWD - REACTION CON			<pre>keV:01/04/7</pre> . FUNC:
	:PRESSURIZATION	ABORT:		
	:MC284-0421-0001/-0			• hwD: 3
-	R: 5760009-101, 576001	U-102 MISSIUNS:	HE VEX EF	UF Siri
.QUANTITY			PL LG X 00 X	
•	ONE REQ'D PER TANK	· · · · · · · · · · · · · · · · · · ·	SUCCESS PATHS R	
•	•		ST FAILURE:	2
•			CREEN: A-N/A	
	ETECTABLE IN FLIGHT?		TIME TO EF	Fills
	DECAY IN PRESS- SYST	EM V42P-1115C AND		F C
.1116C (TAN	(K ULLAGE)			DOCUMENTS:
•			MJG70-C0C1	
.GPOUND TUP	RNAROUND?	••YES	SC72-SH-C1	
.TEST PORT	FOR GROUND CHEC	KOUT AND BACK CHE	CK VS /0-42160	1
•			•	
•				
•	00001000 04-		ADDDENIA CM.	
•	PREPARED BY:	0.00034163	APPROVED SY: DES	
•	DES	R GONZALEZ		
•	REL	R DIEHL	REL	
•				

CDONNO I	VE, PRESS. RELIEF - PRESS 315 PSIG, FULI	BDEN SAB BETC N	ESEAT BLO BLO	10 V
		_ UPEN 340 P316, R	ESEAT SIC PSIG	(1/2 A
101/102) .			
.FUNCTION:	VALVE PROVIDED TO PR	DEVENT OFF OF TAN	IV AME THE BUES	HOEK TO
				OKES 10
	WHICH COULD BE DETRI			
	ODE: EXTERNAL LEAK VERBOARD THRU BELLOW			
	ACKRONKO IUKO ECITO	VS & URIFICE.		•
.CAUSE(S):	C CORROSION, IMPROP	TO TAICTALL ATTOMIZED	MOLTAL EATTLIE	(3D
		ER INSTALLATION/HA	MULTING, FAITOGE	UK.
	RAL FAILURE. : ON (A)SUBSYSTEM (I)	COLON IT MOENZY.	Lacre.
	: UN (A)SUBSTSTEM (I UBSYSTEM DEGRADATIO			
				CONTROLLED
	ICE. (C&D) NO EFF	ECT ONCESS FEAR 13) <u> </u>	
.CORRECTIN		1.055		
	SYSTEM FOR HELIUM	LU33•		
-REMARKS/H	AZAKUS: RA IGENTIETEA.			
. RE 1047A	BU TUENTIETEU			

	SUBSYSTEM Fwd. Reaction	HARDWARE/SOFTWARE			03-2F-101060-2
	ITEM Relief Valve "	COLLET O !	FMEA NUMBER		SD75-SH-0016A
,	· · · · · · · · · · · · · · · · · · ·		WITCHE HODE	DUISC DIS	c <u>Ruptures</u>
1.	DOES THE FLIGHT SOFTWARE DETEC	T THIS FAILURE MODE (†	i.e., AUTOMATICA	LLY	YES X NO
la.	IF NOT, DOES THE HARDWARE PROVUSE TO DETECT THE FAILURE?	IDE INFORMATION THAT T	HE FLIGHT SOFTW	ARE COULD	*YES NO
2.	ARE THE ANSWERS TO OUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND la CONSISTENT WIT	THE FMEA EVAL	UATION OF	YES THE NIO X
3.	DOES THE FLIGHT SOFTWARE TAKE (EITHER BY COMMANDING HARDWARE	ACTION TO NEGATE THE E ACTION OR IMPLEMENTIN	FFECTS OF THE FIG ALTERNATE PRO	AILURE GRAM LOGIC)?	YES NO X
3a.	IF NOT, DOES THE CAPABILITY EX FAILURE MODE (EITHER BY COMMAN PROGRAM LOGIC)?				*YES NO X
4.	AS A RESULT OF THIS FAILURE MO INDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE C	VERSTRESS THE H	ARDWARE OR	*YES NO X
5.	CAN THIS FAILURE MODE, IN COMB OTHER FUNCTIONS?	INATION WITH SOFTWARE	LOGIC, ADVERSEL	Y AFFECT	*YES NO X
6.	HOW MANY OF THESE HARDWARE FAI ACTION AND HARDWARE/SOFTWARE O	LURES CAN THE SHUTTLE PERATION)? NOTE CHANG	TOLERATE (CONSI E TO FMEA CRITI	DER CREW CALITY.	*0 *1 2 X
7.	IF CREW ACTION IS REQUIRED TO TO SIGNAL THE NEED FOR INTERVE	RESPOND TO THIS FAILUR NTION AND THE REQUIRED	E MODE, ARE CUE CORRECTIVE ACT	S PROVIDED ICH?	N/A X YES 1.0
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:			
•	A. CAN THE BFS BE ENGAGED AFT				YES X *110
	B. WILL BFS TOLERATE FAILURE	WITHOUT LOSS OF CREH/V	EHICLE?		YES X *110
~EXP	LANATION REQUIRED (SEE BELOW)	,			
CHAN	GE/RETENTION RATIONALE SUMMARY				
1.[NO H/S ISSUES	3. NO SOFTWARE DE	TECTION		PTANCE RATIONALE BELOW
2. []	HARDWARE ACCEPTS RISK	4. DETECTION DURI	NG CHECKOUT	6. \square RECO	MMENDED CHARGES BELOW
					•
`					
				•	,
	•				
			In-Flight	Detectabil	ity
_			X FMEA CHAN	GE RECOMMEND	
<u>EX</u>	PLANATION/COMMENTS:	· ·	-		
1. ar	. May see discrete drop in nd warning alarm.	RCS quantity. V42	P1115C, 1116C	will give	class 2 caution
			-		

	FWD - REACTION CONTROL		3-2F -101060-2	
	*PRES SURIZATION .	ABCRT:		. FUNC:
	:MC284-0421-0001/-0002			. HWD: 3
	R:5760(09-101,57c0010-10		HE VEX HE	
.QUANTITY			PL X LO X Co X	
•	ONE REQ*D PER TANK		SUCCESS PATHS RE	
•	•		RST FAILURE:	2
•			CREEN: A-PASS 6	
.FAILURE D	ETECTABLE IN FLIGHT?. NO)	TIME TO EFF	-EC1:
•			IMMEDIATE	
•			REFERENCE C	
•			MJG70-0001-	
.GROUND TU	RNAROUND?	3	SD72-SH-G10	
•			VS70-421001	Ĺ
•				
•				
•				
•	PREPARED SY:		APPROVED BY:	
•		R GONZALEZ	DES	
•	REL	R DIEHL	₭ - L	
•				
•				
	VE, PRESS. RELIEF -			15 /
	PRESS 315 PS1G, FULL OPI	EN 340 PSIG, 1	RESEAT SIC PSIG	(KV
101/102)•			
.FUNCTION:		UT DIGE OF T.	ar income a market and a com-	10.71 50
	VALVE PROVIDED TO PREVE			JKES IU
	WHICH COULD BE DETRIMENT			
T	ODE: FAILS OPEN	(;	,	
	ISC RUPTURES.			
.CAUSE(S):		00.00 00.00000	CETTING EATION	r zur ein
	OR PRESSURE SURGE, INCOME CYCLING, VIB, MAT'L D			z. EXCESS
				2TC
•EFFEC ((S)	: ON (4) SUESYSTEM (B) IN	LEKTALES TUIM.	TOTAL TOTAL ENTRE	TIULE:
	OSS OF REDUNDANCY (LEAK,		JUE J (MAIN PUPPLI	PROVIDES
• REDUNDA	· · · · · · · · · · · · · · · · · · ·	•		
.CCRRECTIN		ELTIM LOCK ON	DD DD TANZ BEECE	! #12 m.
_	SYSTEM FOR POTENTIAL H		FRUP + TANK FKESS	コバニ
	E. REPLACE VALVE AFTER	LANUING.		
.REMARKS/H	AZARĐS: ROS IDENTIFISO.			
. NII HAZA	KON HIEMITETELL			

-HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101060-3 SUBSYSTEM Fwd Reaction Control FMEA NUMBER SD75-SH-0016A FAILURE MODE _ Fails to Burst_ ITEM Relief Valve DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY YES X NO 1. ANNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD la. USE TO DETECT THE FAILURE? ARE THE AUSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF 2. IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE l X 3. (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE *YES | NO 3a. PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR *YES NO 4. INDUCE ANOTHER FAILURE? CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT 5. OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 | *1 | 2 | X б. ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. N/A X YES NO IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 5. ACCEPTANCE RATIONALE BELOW 1. NO H/S ISSUES 3. \(\text{NO SOFTWARE DETECTION} \) 6. RECOMMENDED CHANGES BELOW 4. DETECTION DURING CHECKOUT 2. [X] HARDWARE ACCEPTS RISK IFMEA CHANGE RECOMMENDED

1. Over pressurization will cause class 2 alarm; >312 psi. (GAX) V42P1115C, 1116C.

.ASSEMBLY .P/N RI .P/N VENDOR .DUANTITY	:PRESSURIZATION :MC284-0421-030 :5760009-101,57	1/-0602 60010-102 TANK	ABORT: MISSIONS: PHASE(S): NUMBER OF S AFTER FIRST	CX1 CR1 HF VF X FF PL LG X GO SUCCESS PATHS FAILURE:	OF SM X DO X ES REMAINING
.PRESSURE R .1116C (TAN	TECTABLE IN FLI ISE IN HELIUM K ULLAGE NAROUND? TEST PORT	GHT?. YES SYSTEM V42P PRESSURE)	-1115C AND	TIME TO E SECONDS REFERENCE	DCCLMENTS:
• • • • • •	PREPARED BY DES REL	R GO	NZALEZ DIEHŁ	APPROVED BY: DESREL	
CRCKNG P 101/102) .FUNCTION: . RELIEF V LEVELS W .FAILURE MG	E, PRESS. RELIE RESS 315 PSIG, ALVE PROVIDED T HICH COULD BE C DE: FAILS TO E S AT A HIGHER T	FULL OPEN 3 O PREVENT R ETRIMENTAL URST	1SE OF TANK TO SUBSYSTER (_)	AND LINE PRES	
IMPROPER PIECE 'PA .EFFECT(S): .(A) NO E .INTERFAC .WORKING .CCRRECTING .CLOSE HE FIRING T .REMARKS/HA	LIUM ISOLATION HRUSTERS.	SSURE BUILD M (B)INTERF LTIPLE FAIL ROP TANK UL (C,D) N VALVES, HOW	UP ON REVER ACES (C)MISS URES OCCUR. LAGE PRESSUR FONE SEE (A)	RSE SIDE. SION (D)CREW/V (B) DEGRADA RE MAY INCREAS A3OVE. CCULD BE COMP	EHICLE: Tion Of Sc Abuve

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REDUNDANCY PROVIDED.

1

	SUBSYSTEM Fwd Reaction Control	FNEA NUMBER	03-2F-101060-4 SD75-SH-0016A
	ITEM Relief Valve	FAILURE MODEOpe	-
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (1	.e., AUTOMATICALLY	YES X NO
	ANNUNCIATE OR TAKE ACTION IN RESPONSE)?		
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT TO USE TO DETECT THE FAILURE?	HE FLIGHT SUFTWARE COULD	*YES NO
2.	ARE THE ANSWERS TÓ QUESTIONS I AND la CONSISTENT WIT IN-FLIGHT DETECTABILITY?	H THE FMEA EVALUATION OF	YES T *NO X
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE E (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTIN		YES NO X
3 a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE T FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION O PROGRAM LOGIC)?	O COMPENSATE FOR THIS R IMPLEMENTING ALTERNATE	*YES NO X
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE O INDUCE ANOTHER FAILURE?	VERSTRESS THE HARDWARE OF	R *YES NO X
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE OTHER FUNCTIONS?	LOGIC, ADVERSELY AFFECT	*YES NO X
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANG	TOLERATE (CONSIDER CREW E TO FMEA CRITICALITY.	*0 *1 2 X
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILUR TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED	E MODE, ARE CUES PROVIDER CORRECTIVE ACTION?	ON MA MYES X HO
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?		YES X *NO
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/V	EHICLE? .	YES X *NO
*EXP	PLANATION REQUIRED (SEE BELOW)		
CHAN	NGE/RETENTION RATIONALE SUMMARY		•
1.[☐ NO H/S ISSUES	TECTION 5. A	CCEPTANCE RATIONALE BELCK
2.	★ HARDWARE ACCEPTS RISK ★ L □ DETECTION DURI	NG CHECKOUT . 6. A	ECOMMENDED CHANGES BELOW
			•
•			
*		•	
	· ·	In-Flight Detectabi	
. -		X FMEA CHANGE RECOMME	ENDED
EX	XPLANATION/COMMENTS:	•	
	- · · · · ·	•	

1. Leakage of helium will cause an oxidizer/fuel imbalance of 12.6 percent. May get a gross leak detection alarm.

SUBSYSTEM	:FWD - REACTION CON	iTROL FMEA NO (J3-2F -101060-4	REV: 01/04/78
.4SSEMBLY	: PRESSURIZATION	ABURT:	CRIT	· FURL:
.P/N RI	:MC284-0421-0001/-0	CC2	CRIT	. HWU: 3
.PVW VENDOR	R:5760C09-101,576001	.0-102 MISSIONS:	hF VF λ fF.	OE SM
. QUANTITY	: 2	PHASE(S):	PL LOX COX	DO X LS
•	ONE REQ'D PER TANK	NUMBER OF	SUCCESS PATHS R	EMAINING
•	:	AFTER FIF	RST FAILURE:	2
•		REDUNDANCY S	SCREEN: A-	t- C-
.FAILURE DE	ETECTABLE IN FLIGHT?	· NO	TIME TO SH	FECT:
	CESSIVE PRESSUR E DR		SECONES TO	DAYS
.TANKAGE			REFERENCE I	DUCUMENTS:
•		•	MJ070-0001	-618
.SROUND TUR	RNARGUND?	NO	SD72-SH-01	03-2
.SAME AS FL			VS70-42100	Ī
•				
•				
•				
•	PREPARED BY:		APFROVED 6Y:	
•	DE S	R GONZALEZ	DES	
•	REL	R DIEHL	REL	
•				
•				
.ITEM: VAL	VE, PRESS. RELIEF -			
	PRÈSS 315 PSIG, FULI	. OPEN 340 PSIG, I	RESEAT BIC PSIG	(RV
101/102				
.FUNCTION:				
. RELIEF '	VALVE PROVIDED TO PA	REVENT RISE OF TAI	NK AND LINE PRESS	UKES TO
	WHICH COULD BE DETRI			
.FAILURE MI	DOE: PREMATURE/ERRA	ATIC OFERA- (F)	
. TION, I	NTERNAL LEAKAGE, OP	EN BELOW NOMINAL (CRACKING PRESSURE	•
.CAUSE(S):	-			
. VIERATI	ON, MECHANICAL SHOCK	C, CONTAMINATION,	PIECE PART STRUC	TURAL
FAILURE	OF POPPET.			
.EFFECT(S)	: ON (A) SUBSYSTEM (B)INTERFACES (C)M	ISSION (D)CREW/VE	HICL:
. (A) LOS	S OF HELIUM OR PHOPI	ELLANT VAPORS OVE	RBOAKD. (8) INA	EILITY TO
	IZE PROPELLANT TANKS			
	F EARLY IN MISSION,			
OPEN).	(D) NONE.			
.CCRRECTIN				
MONE.				

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. WOULD REQUIRE BURST DISC FAILURE BEFORE LEAKS GVERBOARD. NO KEDUNDANLY

.REMARKS/HAZAROS:

PROVIDEC.

	CHOCYCTCH F.J.D. L. C.	HARDWARE/SOFTWAR				
	SUBSYSTEM <u>Fwd Reaction Co</u> ITEM <u>Relief Valve</u>		FMEA NUMBER FAILURE MODE		75-SH-0016A	
	Nettel valve			rans w.	/perr	
1.	DOES THE FLIGHT SOFTWARE DETECTAINUNCIATE OR TAKE ACTION IN R		(i.e., AUTOMATICA	LLY	YES X NO) [
lá.	IF NOT, DOES THE HARDWARE PROVI USE TO DETECT THE FAILURE?	DE INFORMATION THAT	THE FLIGHT SOFTWA	RE COULD	*YES NO) 🔲
2.	ARE THE ANSWERS TO QUESTIONS I IN-FLIGHT DETECTABILITY?	AND la CONSISTENT W	ITH THE FMEA EVAL	UATION OF	YES X *NO) [
3.	DOES THE FLIGHT SOFTWARE TAKE / (EITHER BY CONMANDING HARDWARE	ACTION TO NEGATE THE ACTION OR IMPLEMENT	EFFECTS OF THE FA	AILURE GRAM LOGIC)?	YES NO	X
3a.	IF NOT, DOES THE CAPABILITY EXT FAILURE MODE (EITHER BY COMMANI PROGRAM LOGIC)?				*YES NO) <u>X</u>
4.	AS A RESULT OF THIS FAILURE MOUINDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE	OVERSTRESS THE H	ARDWARE OR	*YES NO	X
5.	CAN THIS FAILURE MODE, IN COMB: OTHER FUNCTIONS?	INATION WITH SOFTWAR	E LOGIC, ADVERSEL	YAFFECT	*YES NO	X
6.	HOW MANY OF THESE HARDWARE FAIL ACTION AND HARDWARE/SOFTWARE OF				*0 *1	2 X
7.	IF CREW ACTION IS REQUIRED TO I				N/A YESX	110
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:				
	A. CAN THE BFS BE ENGAGED AFTE	ER OCCURRENCE?			YES X *NO	
!	B. WILL BFS TOLERATE FAILURE	WITHOUT LOSS OF CREW	VEHICLE?		YES X *NO	,
*EXP	LANATION REQUIRED (SEE BELOW)					
CHAN	GE/RETENTION RATIONALE SUMMARY		•	•	•	•
		3. NO SOFTWARE	DETECTION	5. 🗆 ACCE	PTANCE RATIONAL	E BELOY
2. [XI HARDWARE ACCEPTS RISK	4. DETECTION DU	RING CHECKOUT	6. 🗆 RECO	MMENDED CHANGES	BELOW
				•		
-						
		•	FMEA CHANG	GE RECOMMENDE	E D	•
-						
<u>E)</u>	PLANATION/COMMENTS:	:	•	,		
1	Over processization will a	cauco a class 2 a	lawm V/1201115C	11160		

	:FWD - REACTION COT :PRESSURIZATION	TRUL FMEA NO ALORT:		5 REV:01/04/7 KIT. FUNC:
.P/N RI	:MC 284-C421-0001/-0	0002	C	KIT. HWE: .3
.P/N VENDOR	R:5760009-101,57600	LO-102 MISSION	S: HF VF X F	F OF SM
.QUANTITY): PL X LO X C	
•	:ONE REQ*D PER TANK		OF SUCCESS PATH	
•	:		IRST FAILURE:	o
•			SCREEN: A-	₽ - C-
.FAILURE DE	ETECTABLE IN FLIGHT	?. YES	TIME TÜ	SFFECT:
	SURE MONITOR V42		REFEREN	TO DAYS CE DOCUMENTS:
•				001-013
	RNAROUND?	•••YES	SD72-SH	
-SAME AS FI	LICHT		VS 70-42	1601
•				•
•				
•				
•	PREPARED BY:		APPRUVED BY	•
•	DE S	R GONZALEZ	DES _	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
•	REL	R DIEHL	REL _	
•				
•				
	VE, PRESS. RELIEF -		2500. 2 014 045	
	PRESS 315 PSIG, FUL	L OPEN 346 PSIG,	RESEAT SIC PSI	6 (RV
161/102	} •			
.FUNCTION:				
	VALVE PROVIDED TO P			=550R=5 10
	WHICH COULD BE DETR			
	ODE: FAILS TO OPEN		F)	
	NAL CRACKING PRESSU	RE .		
.CAUSE(S):				
	NATION, PIECE PART			
	: ON (A) SUESYSTEM (
	S OF RELIEF PATH.			
	DECISION) IF EARLY	IN MISSION WOULD	REQUIRE 2 PRIC	k FAILURES.
.CORRECTIN				
	L THRUSTERS NON-PRO	PULSIVELY.		
.REMARKS/H		•		
	AL TANK RUFTURE ON	3RD ORGER FAILUR	E NO OTHER RELI	EF PATH FOR
SYSTEM.				

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.HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101070-1 SUBSYSTEM Fwd Reaction Control FMEA NUMBER SD75-SH-0016A ITEM ___Fill Ouick Disconnect. Helium FAILURE MODE Fails Open, Cap Leaks 1. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY X NO ANNUNCIATE OR TAKE ACTION IN RESPONSE)?. la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES NO USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS I AND Ia CONSISTENT WITH THE FMEA.EVALUATION OF 2. ______×₩0 IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. YES NO. (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HAROWARE ACTION OR IMPLEMENTING ALTERNATE 3a. *YES NO PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. ***YES** I NO INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT *YES L NO OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 | *1 | X | 2 ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. N/A YES X HO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. \[NO H/S ISSUES 3. \(\subseteq \text{NO SOFTWARE DETECTION} \) 5. ACCEPTANCE RATIONALE BELOW 2. X HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT 6. RECOMMENDED CHANGES BELOW In-flight detectability X FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: 1 & 2. V42P1110C, V42P1112C, V42P1113C and V42P1114C will detect the failure when the pressure drops to 500 psi and issue a class 3 caution and warning alert. Gross leak indication should occur first. (12.6% A) 6. Capped quick disconnect provides one redundant success path.

SUBSYSTEM : FWD - REACTION CONTROL FME4 NO C3-2F -10107G-1 KEV:12/12/7:

.A SSEMELY	: PRES SURIZATION	ABORT:	CRIT. FUNC: 1
P/N PI	:MC276-0017-0402/0403		CRIT. HWC: 1
.PVN VENDO	R:75372000-0402/0463	MISSIONS: H	F VEX FF CF SM
YIITVAUQ.	: 2	PHASE(S): PI	L X LO X OO X DC X LS X
•	ONE REGID PER TANK	NUMBER OF SU	CCESS PATHS REMAINING
•	•	AFTER FIRST	FA1LURE: 1
•	-	REDUNDANCY SCRE	EN: A-N/A B-N/A C-N/A
.FAILURE D	ETECTABLE IN FLIGHT?. NO	0	TIME TO EFFECT:
•			SECONDS TO DAYS
•			REFERENCE DOCUMENTS:
•			MJ07G-G001-01E
.GPDUND TU	RNAKQUND?Y	ES	\$572-\$h-0105-2
.VISUAL IN	SPECTION PRIOR TO LAUNG	CH	VS70-421001
•			
•			
•			
•	PREPARED BY:	4	PPKCVED BY:
•	DE S	C SCARLETT	UES
•	R⊆L	R DIEHL	REL
•			
•			
.ITEM: DIS	CONNECT, QUICK FILL		
• HELIUM	WITH SPRING LOADED POPP	ET AND STRUCTURAL	END CAP (1/4"). (MD
105/106)		
.FUNCTION:			
. PROVIDE	S HELIUM TANK FILL POIN	T FOR GROUND OPER	ATIONS AND LUADING
SERVICE	NG.		
.FAILURE M	ODE: FAILS OPEN, CAP	(2)	
. LEAKS I	N EXCESS OF ACCEPTABLE	RATE.	
.CAUSE(S):			
. VIGRATI	UN, AND LOOSENING OF TH	E RETAINER NUT, I	MPRCPER HANDLING,
MECHANI	CAL SHOCK.		
.EFFECT(S)	: ON (A) SUBSYSTEM (B) IN	TERFACES (C)MISSI	ON (D)CXEW/VEHICLE:
. (A) LOS	S OF REDUNDANCY. (B)	NONE. (C) POTEN	TIAL LAUNCH DELAY
. (MISSIO	N LOSS) IF DETECTED.	(D) POSSIBLE LOSS	OF CKEW/VEHICLE IF
FAILURE	OCCURS PRIOR TO ET SEP	ARATICN.	
.CORRECTIN	G ACTION:		
. REPLACE	OR TIGHTEN END CAP ON	GROUND. NONE AVAL	LABLE IN FLIGHT.
-REMARKS/H			
. DECAUSE	STRUCTURAL CAP IS LOAD	ED OVER THE DISCO	NNECT, THIS FAILURE MODE
	REMOTE IN FLIGHT.		

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM : FWD - REACTION CONTROL FMEA ND 03-2F -101070-1 REV:12/08/78 - ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1 CRIT. HDH: 1 ♣P/N RI :NC276-0C17-0402/0403 HF VF X FF OF SM •P/N VENDOR:75372000-0402/0403 MISSIONS: PL X LO X CO X DO X LS X . OU ANTITY PHASE(S): : 2

:ONE REQ'D PER TANK

B-N/A C-N/A REDUNDANCY SCREEN: A-N/A

APPROVED BY: APPROVED BY/KNASA): .PREPARED BY: Decelet Mr. Karash 12/13/8 .DES C SCARLETT SSM DES .REL C. E. Camer 12/15/17 8 Munter transformer REL REL R DIEHL ΚΆΡΡROVED WITH CHANGES See Section 13.0

.ITEM: DISCONNECT, QUICK FILL

HELIUM WITH SPRING LOADED POPPET AND STRUCTURAL END CAP (1/4"). (MD 105/106)

. FUNCTION:

- PROVIDES HELIUM TANK FILL POINT FOR GROUND OPERATIONS AND LOADING SERVICING.
- .FAILURE MODE: FAILS OPEN, CAP 151
- LEAKS IN EXCESS OF ACCEPTABLE RATE.

.CAUSE(S):

- VIBRATION, AND LOOSENING OF THE RETAINER NUT, IMPROPER HANDLING: MECHANICAL SHOCK.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF REDUNDANCY. (B) NONE. (C) POTENTIAL LAUNCH DELAY (MISSION LOSS) IF DETECTED. (D) POSSIBLE LOSS OF CREW/VEHICLE IF FAILURE OCCURS PRIOR TO ET SEPARATION.
- -DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C; INSPECTION (D)FAILURE HISTORY:
- (A) CAP SEAL DESIGN DETERMINED TO BE ADEQUATE TO PRECLUDE LEAKAGE. DESIGN FACTOR OF SAFETY IS 2.0 X 4000 PSIG MAX WORKING PRESSURE. CAP PLUS COUPLING CONSTITUTES DUAL SEALING. ALL RETAINER NUTS ARE PROPERLY (B) SEALS ARE EXPOSED TO OVER 600 CYCLES TORQUED TO PRECLUDE LOOSENING. DURING DEVELOPMENT. COUPLINGS ARE SUBJECTED TO 600 OPERATIONAL CYCLES IN QUAL TEST. ALL CAPS AND COUPLING LEAK TESTED FOR 3 MIN. AT PRESSURES UP TO 1.25 MAX WORKING PRESSURE DURING ACCEPTANCE TEST. TURNAROUND LEAK CHECKS PERFORMED BEFORE EACH FLIGHT. RANDOM VIBRATION PERFORMED DURING 68 MINUTES IN THO AXES AT ANTICIPATED MISSION LEVELS. QUAL PROGRAM. TURNAROUND INSPECTION INCLUDES VISUAL INSPECTION ALL COUPLINGS THAT HAVE BEEN USED DURING TURNAROUND FOR DAMAGE PLUS INSPECTING FOR LEAKS DURING LEAK CHECKS. ALSO, PROPER BLEED SCREH TORQUE IS VERIFIED PRIOR SUPPLIER AUDIT TO REINSTALLATION OF ANY CAPS THAT HAVE BEEN REMOVED. CONDUCTED 4-5-77 VERIFIED THAT SUPPLIER INSPECTION CONTROLS RAW MATERIAL PARTS IDENTIFICATION, MFG PROCESSES, CONTAMINATION CONTROL, AND STORAGE ENVIRONMENTS. (D) NEW DESIGN FOR SHUTTLE APPLICATION. NO FLIGHT FAILURE HISTORY

HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101070-2 SD75-SH-0016A SUBSYSTEM _ Fwd. Reaction Control FMEA NUMBER FAILURE MODE Fails Closed/Ground OPS ITEM Quick Fill Disconnect, He. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY 1. YES NO ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO QUESTIONS I AND IA CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTMARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE YES (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS 3a. ***YES** КO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE LARDWARE OR 4. ***YES** 110 INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT .*YES 7.0 OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. N/A YES (10) TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. \[\text{NO H/S ISSUES} 3. \(\subseteq \text{NO SOFTWARE DETECTION} \) 5. ACCEPTANCE RATIONALE BELOW 6. ☐ RECOMMENDED CHANGES BELOW 2. HARDWARE ACCEPTS RISK 4.

DETECTION DURING CHECKOUT FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: Out of Scope. Ground operations only.

	:FWD - REACTION CON			
	: PRES SURIZATION	ABORT:		• FUNC:
	:MC276-C017-0402/04			. HWD: 3
	R: 75372000-0402/0403		S: HF VF X FF	
YTIT% 4UQ.): PL X LG 00	
•	ONE REQ D PER TANK	-	OF SUCCESS PATHS R	
•	:		IRST FAILURE:	0
		-	SCREEN: A-N/A	
*PAILURE DI	ETECTABLE IN FLIGHT?	• N/A.	TIME TO EF	FEC 1:
•			STALGEMMI	
•				DUCUMENTS:
•			MJG70-6001	
	RNAKGUND?		SD72-SH-C1	
•GSE FILL I	RATE AND HELIUM PRES	SURE	V\$70-42100	1
•				
•				
•	00554050 044		- 20 C 24 C 2 - 4 C	
•	PREPARED EY:	# AA.B ETT	APPROVED bY:	
•	D <u>=</u> S	C SCARLETT	DES	
•	REL	R DIEHL	₹EL	
•				
* ****** *****	CONNECT OUTON STILL	•		
	CONNECT, GUICK FILL	5555 TT - 1816 - CT 5110	7.1541 1315 6315 43.77	76.3 f.4.3
1 05/106	MITH SPRING LOADED P)	UPPET AND STRUC	TURAL END CAP 1174	F"). (ND
.FUNCTION:				
	S HELIUM TANK FILL P	DINT FOR GROUNS	OPERATIONS AND LO	ADING
SERVICI	NG.			
.FATLURE M	ODE: RESTRICTED FLO	₩ (F)	
. FAILS C	LOSED DURING GROUND	FILL OPERATIONS		
.CruSE(S):				
. VIBRATI	CN/IMPROPER HANDLING	WHICH CAUSES F	TILTER/POPPET CAMAG	ez IN
DISCONN	ECT.			
.EFFECT(S)	: UN (A) SUBSYSTEM (E)INTERFACES (C)	MISSION (D)CREW/VE	Hīcle:
	S OF OR REDUCED HELI			
. DELAY.	(D) NONE.			
.CGRRECTIN				
,	REPLACE FILL VALVE O	R ATTEMPT TO KE	ECOUPLE.	
.REMARKS/H				
_	D SECUNDANCY DOONTDE	n con Tuto ITEN	EOSIM ZEUT MT A	



SUBSYSTEM Fwd. Reaction Control SD75-SH-0016A FMEA NUMBER ITEM Purge Quick Disconnect, Propellant FAILURE MODE External Leakage During Flight 1. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY X NO YES ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES NO USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO QUESTIONS I AND Ia CONSISTENT WITH THE FREA EVALUATION OF IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE X YES NO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTMARE TO COMPENSATE FOR THIS 3a. X *YES Ж0 FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? 4. AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR Χ *YES INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT X *YES OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 | ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. 7. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YES X 1:0 TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. \[NO H/S ISSUES 3. \(\sum \) NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 2. X HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT 6. RECOMMENDED CHANGES BELOW X FMEA CHANGE RECOMMENDED **EXPLANATION/COMMENTS:** 1. Per backup flight system program requirements document MG038103, once a pre-set delta between the propellant quantities is reached a class 2 caution and warning light and tone will be annunciated. Also primary flight control requirements FSSR 0026A except OPS 1,6. The above statement indicates in-flight detection. Capped quick disconnect provides one redundant success path.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST

03-2F-101080-1

	:FWD - REACTION CONTROL			
	: PRESSURIZATION	ABGRT:	CrIT. FUNC:	_
	:MC276-CC18		CRIT. HWD:	1
.P/N VENDOR		MISSIONS: H	F VEX FF OF SM PL LOX OUX DOX LS	•
.GUANTITY				
	TWO INLETS AND FIVE			
•	: OUTLETS FOR EACH PROP			4
		REDUNDANCY SCRE		-///
.FAILURE DE	ETECTABLE IN FLIGHT?. NO		TIME TO EFFECT:	
•			SECONDS TO DAYS	
•		•	REFERENCE DOCUMENTS:	;
•		_	MJC70-CGC1-018	
	RNARCUND?YE	S	5072-SH-7103-2	
.VISUAL INS	PECTION		VS70-421061	
•				
•				
•				
•	PREPARED BY:	A	PPROVED BY:	
•		\$CARLÈTT	DéS	
•	Ŕ⋶Ļ	R DIEHL	REL	
•				
*	D. 105.7	, 120mg		
*1 (FW: 012C	CONNECT, QCK, PURGE,	1)2		
a Amicia Li	ACCEPTAGE WITH STRUCTORY	F DAD CAL WIND DU		
	(MD 117,118,123,124,12	7,137,138,147,16	01,162,163,154).	
.FUNCTION:	t or allog bloom an angel			
	V GROUND PURGE OF PROPEL			
	DS/LINES/THRUSIERS AFTER	LANDING & PRUPE	ELLANT TANKS FILL, UKAT	¥
TMBV 3	THE STEPHEN FOR THE			
	DE: EXTERNAL LEAKAGE	(5)		
. DURING F	-Cleui			
.CAUSE(S):	no the recentione of the	mentarated by an area	THE STATE OF THE S	. .
	ON AND LOGSENING OF THE			. =
	ILURE MECHANICAL SHOCK,			
	ON (A) SUBSYSTEM (B) INT			
	S OF PROPELLANT FIRST OR			
	FIRE/EXPLOSION IF FUEL			
	HEAT CURING RE-ENTRY).(
	ION. (D) POSSIBLE LOSS	OF CKEMY VEHICLE	IF FAILURE UCCURS PRIOR	`
	EPARATION.			
.CORRECTING		elt e - ድቡፕ ችንድ ዶ፣ ችችነ	A TE LECE CEUIDE SE AST	
	AILASLE - IN FORWARD MOD	ULE, CKITICALITY	1 10 FE90 SEACKE TH WHI	
	OPERATIVE .			
. YEMARKS/HA	AZAKUSI			

. POTENTIAL CORROSION OF SURROUNDING COMPONENTS. STRUCTURAL CAP

CONSIDERED AS STRUCTURE.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -101080-1 REV: 12/08/7 CRIT. FUNC: .ASSEMBLY :PRESSURIZATION ABORT: 1 CR IT . 1 .P/N RI :XC276-0018 HOH: .P/N VENDOR:76306000 MISSIONS: HF VF X FF 0F SM PHASE(S): PL LO X OC X DO X LS .QUANTITY :TWO INLETS AND FIVE **COUTLETS FOR EACH PROP** A-N/A REDUNDANCY SCREEN: C-N/A B-N/A APPROVED BY/(NASA) APPROVED BY: .PREPARED BY: 72/13/8 C. Same 12/13/8 Nin SSM .DES C SCARLETT DES . REL R DIEHL REL REL - ROPL- Driver AAAKOVED WITH CHANGES

.ITEM: DISCONNECT, QCK, PURGE,

 VENT, PROPELLANT WITH STRUCTURAL END CAP AND SPRING LOADED POPPET (1/2"). (MD 117,118,123,124,127,137,138,147,161,162,163,164).

.FUNCTION:

TO ALLOW GROUND PURGE OF PROPELLANT TANKS AND ASSOCIATED
 MANIFOLDS/LINES/THRUSTERS AFTER LANDING & PROPELLANT TANKS FILL, DRAIN
 & VENT

.FAILURE MODE: EXTERNAL LEAKAGE (S)

DURING FLIGHT

.CAUSE(S):

- . VIBRATION AND LOOSENING OF THE RETAINER NUT, STRUCTURAL FAILURE, PIECE PART FAILURE MECHANICAL SHOCK, IMPROPER GROUND HANDLING.
- .EFFECT(S): ON (A) SUBSYSTEM (B)INTERFACES (C) MISSIGN (D)CREW/VEHICLE:
- (A) LOSS OF PROPELLANT FIRST ORDER FAILURE FOR LOOSE RETAINER NUT. (B) POSSIBLE FIRE/EXPLOSION IF FUEL REACTS WITH COMPLEMENTARY OXIDIZER (OR EXTREME HEAT DURING RE-ENTRY).(C) POSSIBLE LOSS OF MISSION DUE TO FLUID SEPARATION. (D) POSSIBLE LOSS OF CREW/VEHICLE IF FAILURE OCCURS PRIOR TO ET SEPARATION.
- .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
- (A) CAP SEAL DESIGN DETERMINED TO BE ADEQUATE TO PRECLUDE LEAKAGE. DESIGN FACTOR OF SAFETY IS 3.0 X 710 PSIG MAX WORKING PRESSURE. CAP PLUS COUPLING CONSTITUTES DUAL SEALING. ALL RETAINER NUTS ARE PROPERLY TORQUED TO PRECLUDE LOOSENING. (B) SEALS ARE EXPOSED TO OVER 500 CYCLES DURING DEVELOPMENT. COUPLINGS ARE SUBJECTED TO 600 OPERATIONAL CYCLES IN QUAL TEST. ALL CAPS AND COUPLINGS LEAK TESTED FOR 3 MINUTES AT PRESSURES UP TO MAX WORKING PRESSURE DURING ACCEPTANCE TEST. TURNAROUND LEAK CHECKS PERFORMED BEFORE EACH FLIGHT. RANDOM VIBRATION PERFORMED DURING QUAL PROGRAM. 68 MINUTES IN TWO AXES AT ANTICIPATED (C) TURNAROUND INSPECTION INCLUDES VISUAL INSPECTING MISSION LEVELS. ALL COUPLINGS USED DURING TURNAROUND FOR DAMAGE PLUS INSPECTING FOR ALSO, PROPER BLEED SCREW TORQUE IS VERIFIED LEAKS DURING LEAK CHECKS. PRIOR TO REINSTALLATION OF ANY CAPS THAT HAVE BEEN REMOVED. SUPPLIER AUDIT CONDUCTED 4-5-77 VERIFIED THAT SUPPLIER INSPECTION CONTROLS RAW MATERIAL PARTS IDENTIFICATION, MFG PROCESSES, CONTAMINATION CONTROL, AND STORAGE ENVIRONMENTS. (D) NEW DESIGN FOR SHUTTLE APPLICATION. FLIGHT FAILURE HISTORY.

See Section 13.0

HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101080-2

SUBSYSTEM Fwd. Reaction Control FMEA NUMBER SD75-SH-0016A

ITEM Purge Quick Disconnect, Propellant FAILURE MODE Fails Closed/Ground Ops.

DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY YES NO

			 	
1.	DOES THE FLIGHT SOFTWARE DETECTANNUNCIATE OR TAKE ACTION IN RE	T THIS FAILURE MODE (i.e., AUTOMATICAL	LY	YES NO
la.	IF NOT, DOES THE HARDWARE PROVIUSE TO DETECT THE FAILURE?	DE INFORMATION THAT THE FLIGHT SOFTWAR	RE COULD	*YES NO
2.	ARE THE ANSWERS TO QUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND TO CONSISTENT WITH THE FMEA EVALU	ATION OF	YES *NO
3.		ACTION TO NEGATE THE EFFECTS OF THE FA ACTION OR IMPLEMENTING ALTERNATE PROG		YES NO
3a.	IF NOT, DOES THE CAPABILITY EXT FAILURE MODE (EITHER BY COMMAND PROGRAM LOGIC)?	IST FOR THE SOFTWARE TO COMPENSATE FOR DING HARDWARE ACTION OR IMPLEMENTING A	THIS LTERHATE	*YES NO
4.	AS A-RESULT OF THIS FAILURE MOUINDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE OVERSTRESS THE HA	RDWARE OR	*YES NO
5.	CAN THIS FAILURE MODE, IN COMBIOTHER FUNCTIONS?	NATION WITH SOFTWARE LOGIC, ADVERSELY	AFFECT	*YES 110
6.	HOW MANY OF THESE HARDWARE FAIL ACTION AND HARDWARE/SOFTWARE OF	URES CAN THE SHUTTLE TOLERATE (CONSID PERATION)? NOTE CHANGE TO FMEA CRITIC	ER CREW ALITY.	*0 *1 2
7.	IF CREW ACTION IS REQUIRED TO F TO SIGNAL THE NEED FOR INTERVEN	RESPOND TO THIS FAILURE MODE, ARE CUES	PROVIDED N	I/A YES RO
8.	IF THE ANSWER TO EITHER 1 OR 3	IS VES-		
٠.		•		una Claus El
				YES *KO
		VITHOUT LOSS OF CREW/VEHICLE?		YES *110
*EXP	LANATION REQUIRED (SEE BELOW)	•		
CHAN	CE/DETENTION DATIONALE CHIMADA			
	GE/RETENTION RATIONALE SUMMARY	a ET No corrupt person	# F7 #00F0F4	INOC DATTONNI S ASLAN
	NO H/S ISSUES	3. NO SOFTWARE DETECTION		NICE RATIONALE BELOW
2.] HARDWARE ACCEPTS RISK	4. DETECTION DURING CHECKOUT	6. LI RECOMME	ENDED CHANGES BELOW
		•		
•				
		FMEA CUAMC	E RECOMMENDED	
_			L NEGOTATEROCO	
EX	PLANATION/COMMENTS:			•
1.	Out of scope/ground opera	tions only.		

SUBSYSTEM	:FWD - REACTION CONT	ROL FMEA NO 03	3-2F -101080-2 REV:05	166/7:
	:PRESSURIZATION	ABORT:	CRIT. FUNC:	
	:MC276-0018		CRIT. HWD:	
.P\N VENDOR			HE VEX FF CF SM	
YTITMAUC.			PL X LG OU DO LS	
			SUCCESS PATHS REMAINING	;
•	COUTLETS FOR EACH PR			1
•				C-X/Y
.FAILUFE DE	ETECTABLE IN FLIGHT?.	N/A	TIME TO EFFECT:	
•			IMMEDIATE	
•			REFERENCE DUCUMENT	5:
•			MJ070-0001-01E	
	RNAROUND?		SD72-SH-0103-2	
	MENT FLOW RATE AND		VS70-421001	
.PRESSURE \	/42F-1210C, 13100			
•				
•			5 . 2.172	
•	PREPARED BY:		APPROVED BY:	
•	DES	C SCARLETT	DES	
•	REL	R DIEHL	REL	
•				
	CONNECT, QCK, PURGE,	TOO 1	003310 L010 10 10000 T	
•			SPRING LOADED POPPET	
	(MD 117,118,123,12	4,127,137,138,147	,161,152,163,1641.	
.FUNCTION:		Service of the servic		
	A GROUND PURGE OF PRO			. 7 .
MANIFOL! & VENT	US/LINES/THRUSTERS AT	FTER LANDING & PR	OPELLANT TANKS FILL, UK,	41N .
.FAILURE MI	ODE: FAILS CLOSED	(F)		
. DURING	GROUND SPERATIONS			
.CAUSE(S):				
	NATION PIECE PART ST	RUCTURAL FAILURE,	MECHANICAL SHOCK.	
.EFFECT(S)	: ON (A) SUES YSTEM (E)INTERFACES (C)MI	SSION (D)CREW/VEHICLE:	
			(C) POTENTIAL LAUNCH	
	(D) NONE.			
.CORRECTIN				
		(BACK-FLOW) OR RE	MOVE COUPLING AND REPLACE	St
.P EMARKS/H				
. NONE. N	G REDUNDANCY PROVIDE	D FOR THIS ITEM.		

	SUBSYSTEM Fwd. Reaction (HARDWARE/SOFTWAR Control	E ANALYSIS CHEC		03-2F-101090-1
	ITEM Test Quick Disconnect				ge/Flight
1.	DOES THE FLIGHT SOFTWARE DETEC	T THIS FAILURE MODE ESPONSE)?	(i.e., AUTOMATICAL	LY	YES X NO
la.	IF NOT, DOES THE HARDWARE PROVUSE TO DETECT THE FAILURE?	IDE INFORMATION THAT	THE FLIGHT SOFTWA	RE COULD	*YES NO
2.	ARE THE ANSWERS TO OUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND la CONSISTENT W	ITH THE FMEA EVALU	JATION OF	YES *NO
3.	DOES THE FLIGHT SOFTWARE TAKE (EITHER BY COMMANDING HARDWARE				YES NO X
3a.	IF NOT, DOES THE CAPABILITY EX FAILURE MODE (EITHER BY COMMAN PROGRAM LOGIC)?				*YES NO X
4.	AS A RESULT OF THIS FAILURE MO INDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE	OVERSTRESS THE HA	ARDWARE OR	*YES NO X
5.	CAN THIS FAILURE MODE, IN COMBOTHER FUNCTIONS?	INATION WITH SOFTWAR	E LOGIC, ADVERSELY	AFFECT	.*YES NO X
6.	HOW MANY OF THESE HARDWARE FAI ACTION AND HARDWARE/SOFTWARE O	LURES CAN THE SHUTTLE PERATION)? NOTE CHA	E TOLERATE (CONSID IGE TO FMEA CRITIC	DER CREW	*0
7.	IF CREW ACTION IS REQUIRED TO TO SIGNAL THE NEED FOR INTERVE	RESPOND TO THIS FAIL	JRE MODE, ARE CUES	PROVIDED	N/A YESXIIO
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:			
	A. CAN THE BFS BE ENGAGED AFT				YES X *110
			ALEUTOL ES		
	B. WILL BFS TOLERATE FAILURE	MITHOUT LOSS OF CKEN,	AFHICE;		YES X *NO
*EXF	LANATION REQUIRED (SEE BELOW)				
OUA	OF ARTENTION DATIONALE CHAMBA				
	GE/RETENTION RATIONALE SUMMARY				
	NO H/S ISSUES	-		-	PTANCE RATIONALE BELOW
2. [☑ HARDWARE ACCEPTS RISK	4. ☐ DETECTION DU	RING CHECKOUT	6. RECO	MMENDED CHANGES BELOW
•		•			
			•		
			TEMEA CHANG	SE RECOMMEND	FN
_					
EX	PLANATION/COMMENTS:				
		4 VAODIII 200	4		
10	& 2. V42P1110C, V42P1112C	and vazrilist wil	detect the fa	ilure and	issue class 3 alarm
	ystem management blue light		giare shield) a	i <ouu psi<="" td=""><td>d.</td></ouu>	d.
Gr	oss leak indication is quid	cker (class 2).			
_					
6.	Capped quick disconnect	provides one redu	ndant success p	ath.	•

Y LERTSZA. PON RI NODON NAGO YTITNAJO.	:FWD - REACTION CO :PRESSURIZATION :ME276-0032 R:RR42670-587,R6429 :14 :SEVEN REC'D FOR E :PROPELLANT	ABOR OC-1&3 MISS PHAS ACH NUMB AFTE	T: IONS: HF VI E(S): PL Lí ER OF SUCCESS R FIRST FAILU!	CRIF. FUNC: CRIT. HWL: F X FF GF SM D X OU X DO X LS PATHS REMAINING RE:	1 1 1 1 1 2-PAS1
.HELIUM TA; .1114C	ET_CTAELE IN FLIGHT NK PRESSURE V42 RNAROUND?	?. YES P-1110C,1112C	,1113C, SEC REI	ME TO EFFECT:	-
•	PREPARED BY: DES REL	C SCARLET R DIEH	APPROVI T DI L RI	- · · · · ·	
• P1. (1/4 163,164 • FUNCTION: • T0 PRGV SYSTEM: PROVIDE:	CONNECT, QUICK, TES 4") WITH SPRING LOA ,107,108,109,110,11 IDE ACCESS TO THE F (1) RELIEF VALVES/ S FOR C/O OF PRESSU	DED POPPET AN 1,112,115,114 HELIUM SUPPLY MBURST DISCS (PRIZATION SUB-	,177 & 173). SYSTEM AT VAR 2) REGULATORS SYS COMPONENT:	IOUS POINTS IN TH	nč
.FAILURE MI . DURING .CAUSE(S): . VIBPATIO SHOCK.	ON, PIECE PART STRU	KAGE UCTURAL FAILUR	(S) E (POPPET, SE		
• (A) LOS • PROPELL FLUID L LOSS OF	ON (A) SUBSYSTEM (S OF HELIUM PRESSUR ANT FEED CAPABILITY OSS. (D) NONE. (E HELIUM SUPPLY WHICH DEFORE ET SEPARATE ACTION!	RANT. (SECOND (. (C) POTEN E) FUNCTIONAL CH COULD RESUL	ORDER FAILURE TIAL LOSS OF CRITICALITY E). (6) LGSS OF MISSION DUE TO FFECTS - POTENTIA	
	AFT MEDULES TO URI	ENT VEHICLE F	OR ENTRY AND	COMPLETE ABORT.	

. NONE.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

FMEA NO 03-2F -101090-1 REV: 11/09/ SUBSYSTEM :FWD - REACTION CONTROL CRIT. FUNC: 13 .ASSEMBLY :PRESSURIZATION ABORT: CRIT. HOW: 3 .P/N RI :ME276-0032 VEX FF OF .P/N VENDOR:RR42670-5&7,R642900-1&3 = SNOIZZIH HF LO X CO X DO X LS PHASE(S): PL :14 _OUANTITY SEVEN REQID FOR EACH :PROPELLANT REDUNDANCY SCREEN: 4-PASS B-FAIL C-PA APPROVED ET INASALT APPROVED BY:
DES C. SCALET 14/1/8 .PREPARED BY: C SCARLETT -DES C. E. Dassen Just 878 RE**₹** R DIEHL REL .REL APPROVED WITH CHANGES See Section 13.0 .ITEM: DISCONNECT, QUICK, TEST (MD 101, 102, PT. (1/4") WITH SPRING LOADED POPPET AND STRUCTURAL CAP. 103.104.107.108.109.110.111.112.113.114.177 & 1781. _FUNCTION: TO PROVIDE ACCESS TO THE HELLUM SUPPLY SYSTEM AT VARIOUS POINTS IN THE SYSTEM: (1) RELIEF VALVES/BURST DISCS (2) REGULATORS (3) CHECK VALVES. PROVIDES FOR C/O OF PRESSURIZATION SUB-SYS COMPONENTS. COMPONENT INPUTS & OUTPUTS ARE ACCESSABLE AT HE SERVICE PAMEL. .FAILURE MODE: EXTERNAL LEAKAGE DURING FLIGHT .CAUSE(S): VIBRATION, PIECE PART STRUCTURAL FAILURE (POPPET, SEAL), MECHANICAL SHOCK. . EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE: (A) LOSS OF HELIUM PRESSURANT. (SECOND ORDER FAILURE). (9) LOSS OF (C) POTENTIAL LOSS OF MISSION DUE TO PROPELLANT FEED CAPABILITY. (D) NONE. (E) FUNCTIONAL CRITICALITY EFFECTS - POTENTIAL FLUID LOSS. LOSS OF HELIUM SUPPLY WHICH COULD RESULT IN LCSS OF VEHICLE IF THE LOSS OCCURRED BEFORE ET SEPARATION. -DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (A) DUAL SEALING SURFACES ON CAP WILL PRECLUDE FAILURE. EACH SEALING SURFACE INDEPENDANT OF THE OTHER DESIGN BURST PRESSURE IS TWO TIMES GPER PRESSURE. (8) EACH COUPLING PROOF TESTED TO AT LEAST 1.5 OPER PRESSURE

SD75-SH-0016A SUBSYSTEM <u>Fwd</u>. Reaction Control FMEA NUMBER ITEM Test Quick Disconnect, Propellant FAILURE MODE Fails Closed/Ground Ops ٦. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY 110 ANNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS I AND IA CONSISTENT WITH THE FMEA EVALUATION OF 2. IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. YES (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE *YES PROGRAM LOGIC)? 4. AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR *YES INDUCE ANOTHER FAILURE? CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT 5. OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW б. ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. 7. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YES 100 TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. NO H/S ISSUES 3. MO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 2. HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT ☐ RECOMMENDED CHANGES BELOW FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: Out of scope - ground operations only.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST

03-2F-101090-2

SUBSYSTEM ASSEMBLY				FMEA NO ABORT:			I-2 CRIT.		16/7:
·P/N RI				,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				r:WU:	3
PIN VENDOR			531-0	MISSIONS	S: HF				_
•DUANTITY				PHASE(S)				D LS	
	SEVEN REG	DO FOR EAC	CH C						
	:PROPELLAN			AFTER F		-			1
•		••	RE	DUNDANCY			55 8-	NZA C	-PAS!
.FAILURE DE	ETECTABLE I	N FLIGHT?					O EFFE		
•			•				s to H		
•							_	CUMENTS	S :
_							-0001-0	_	
. GROUND TUE	RNAROUND?		-YES			5072-5			
.NU FRESSUE				11120,113					
•1114C			,	,	•				
•									
•							•		
•	PREPAR	RED BY:			APP	RGVED E	3 Υ :		
•	I	DES	C SC	ARLETT		DES			
•		REL		DIEHL		REL			
•									
•									
.ITEM: DISC	CONNECT. O	JICK, TEST							
. PT. (1/4				ET AND ST	TRUCTUR	AL CAP	. (MD	101,100	2,
103,104	107,108,19	09,110,111	112,11	3,114,17	7 E 17E).		•	
.FUNCTION:			•						
. TG PROVI	IDE ACCESS	TO THE HEI	LIUM SU	PPLY SYS	TEM AT	VARIOUS	S POINT	S IN TH	1 <u></u>
SYSTEM:	(1) RELIE	F VALVES/B	URST 51	SCS (2) 1	REGULAT	OKS (3)) CHECK	C VALVE	S.
PROVIDE:	S FOR C/O	OF PRESSUR	IZATION	SUB-SYS	COMPON	LNTS.	COMPON	₹ENT	
INPUTS (STUPTUG 3	ARE ACCESS.	ABLE AT	HE SERV	ICE PAN	£L.			
.FAILURE MO					F)				
. DUR ING			PERATIO	NS					
.CAUSE(S):									
. CONTAMI	NATION, PI	ECE PART S	TRUCTUR	AL FAILU	RE (POP	PET, S	EAL).		
.EFFECT(S)	ON (A) SU	BSYSTEM LE)INTERF	ACES (C)	MISSION	(D)CR	W/VEnl	CLE:	
. (A) LUS									
. REQUIRE									
.CORKECTING	G ACTION:								
. TEST AT		POINT (IF	AVAILA	ELE) OR	REMOVE	AND RE	PLACE C	SOJELIM	6 .
.REMARKS/H	AZARDS:								
. NONE									



SUBSYSTEM Fwd. Reaction Control FMEA NUMBER SD75-SH-0016A ITEM Helium Quad Check Valve FAILURE MODE <u>Fails</u> Open 1. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES МО USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF X *110 IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE 3. X (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERMATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS 3a. *YES N0 FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. *YES 110 X I INDUCE ANOTHER FAILURE? CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT 5. X OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 | | *1| | 2 X ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. N/A X YES NO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: CAN THE BFS BE ENGAGED AFTER OCCURRENCE? X *110 B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREM/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 3. NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 1. X NO H/S ISSUES 6. RECOMMENDED CHANGES BELOW 4. DETECTION DURING CHECKOUT 2. HARDWARE ACCEPTS RISK FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: Series redundant. Series redundant.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-101095-1

SUSSYSTEM ASSEMBLY P/N RI	:PRESSURI	ACTION CON' ZATION 81-0001/-00		FMEA NO C	:3-2F -:	CR1	REV:11 T. FUNC: T. HWE:	3
•P/N VENDOS			UUZ	MISSIONS:	HF		OF SM	
QUANTITY		,					X DO X LS	
•		HELIUM SUPI	FLY .				REMAINING	
•	:			AFTER FIR	ST FAIL	_URE:		1
•				DUNDANCY S	CREEN:	ALV-A	AZN-3	C-N/A
*FAILURE DE	ETECTABLE :	IN FLIGHT?	• NO			TIME TO 3	FFECT:	
•						MINUTES		
•							DOCUMENT	5:
•						4J070-050		
•GROUND TUP		•••••	YES			SD72-Sh-C		
•GPOUND TES	ST PORTS				,	v\$70-4210	001	
•								
•								
•	5.665.41	n=0 0v-			* O D D			
•		RED BY:	- r.,		APPR	:Y8 G3VC		
•		DE S		RKHART		DES		
•	1	REL	к	DIEHL		ጻደኒ		,
•								
TTOMP MAIN	IS OUND ON	crv Uc						
.ITEM: VALV	-	EUNAME						
. FUNCT ION:	1021							
. TO PRECI	HOE PROPE	LLANT VARO	MORAL 24	MICRATING	: TA KE	CHATCES	LEKOM THE	
	ANT TANK).	LLANT VATO	NG 1 NO.5	MIGNATING	3 10 1(1)	SOCA FERS	THOM THE	
.FAILURE MO		SOPEN		(F)	1			
• OR FAILS			TNTERNA	• • •	,			
.CAUSE(S):	, , , , , , , , , , , , , , , , , , , ,	020120 (2	L LLAMOL,	, ,			
. CONTAMIN	IV . NOITAV	SRATION. P	IECE PA	RT STRUCTU	BAL FA	ILURE, Ma	Chanlual	
	VIBRATION.							
· EFFECT(S):		BSYSTEM (B) INTERF	ACES (C)MI	ISSION	(D)CREW/	/EdlCLa:	
. (A) LOS	S OF REDUN	DANCY-SERI	ES VALV	E WILL PRO	OTECT R	EGULA TORS	FRUM	
 VAPORS. 	(6,C,D)	NO EFFECT	UNLESS	MULT 1 PLE	FAILUR	ES DOCUR.	, (±)	
FUNCTION	NAL CRITIC	ALITY EFFE	CT - PO	SSIBLE COM	AMINAT	TION OF A	LEGULATURS	+
WITH PRO	DPELLANT V	APORS IF 6	OTH CHE	CK VALVES	ARE OP	EN.		
.CORRECTING								
. VA BUCK								
REMARKS/H								
. NO HAZAI								
ACTION (OF PROPELL	ANT VAPORS	AND CO	NTAMINATIO	on.			

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	SUBSYSTEM Fwd Reaction Control	TWARE ANALYSIS CHE		3-2F-101095-2 D75-SH-0016A	
	ITEM Helium Quad Check Valve			losed	
1:	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MAINUNCIATE OR TAKE ACTION IN RESPONSE)?	40DE (i.e., AUTOMATICAN	ĹY	YES NO	X
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION USE TO DETECT THE FAILURE?	THAT THE FLIGHT SOFTWA	RE COULD	*YES \ NO	
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTE IN-FLIGHT DETECTABILITY?	ENT WITH THE FMEA EVALU	JATION OF	OK* T 23Y	X
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLE	THE EFFECTS OF THE FA	AILURE GRAM LOGIC)	YES NO	
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFT FAILURE MODE. (EITHER BY COMMANDING HARDWARE AC PROGRAM LOGIC)?	TWARE TO COMPENSATE FOR CTION OR IMPLEMENTING A	R THIS X ALTERNATE	*YES \[\] NO	X
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFT INDUCE ANOTHER FAILURE?	WARE OVERSTRESS THE H	ARDWARE OR	*YES NO	X
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOF OTHER FUNCTIONS?	TWARE LOGIC, ADVERSELY	AFFECT	*YES \[\] NO	X
б.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE	NUTTLE TOLERATE (CONSIDE CHANGE TO FMEA CRITIC	ER CREW	*0 *1 X	2
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS TO SIGNAL THE NEED FOR INTERVENTION AND THE RE			N/A YES IN	0 🗌
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	•			
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	CDCU MEUTOL ES	-	YES ***********************************	
. * FYP	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF LANATION REQUIRED (SEE BELOW)	•		YES*NO	لسا
	GE/RETENTION RATIONALE SUMMARY				•
	☐ NO H/S ISSUES				
2. [2	☐ HARDWARE ACCEPTS RISK 4. ☐ DETECTION	JN DURING CHECKOUT	b. L. KEU	OMMENDED CHANGES	RELUM
		.•			
		FMEA CHANG	E RECOMMEN	DED	
EX	PLANATION/COMMENTS:				·-
l & wil	2. Upon using the thrusters, tank ullag I give a class 2 caution and warning alar	e pressure will dec m.	ay until	<200 psi which	

SUBSYSTEM	:FWD - REACTION CONT	TROL FMEA NO 03	-2F -101095-2 REV:11/	'10/7:
.4 SSEMBLY	:PRESSURIZATION	ABORT:	CKIT. FUNC:	1k
.P/V RI	:MC284-0481-0001/-00	002	CRIT. HWD:	3
.P/N VENDOR	R:KS010500-001/-011	Misslons:	HE VEX HE OF SM	
.QUANTITY	:2	PHASE(S):	PL LO X DO X DU X LS	
•	:ONE PER HELIUM SUPE	PLY NUMBER OF	SUCCESS PATHS REMAINING	
•	:	AFTER FIRS	T FAILURE:	1
•		REDUNDANCY SC	REEN: A-PASS B-FAIL C	-FAIL
.FAILURE DE	ETECTABLE IN FLIGHT?	• NO	TIME TO EFFECT:	
.DUE TO SMA	ALL PITHE LEAKA	AGE IS NOT DETEC-	MINUTES	
•TASLE			REFERENCE DOCUMENTS	, :
•			MJC70-0001-01E	
	RNAROUND?		SD72-Sh-0103-2	
.SAME AS FL	IGHT INSTRUMEN TATIO	ρŅ	VS70-421601	
•				•
•				
•				
•	PREPARED EY:	_	APPROVED BY:	
•	D≣S	R BURKHART	DES	
•	RãL	R DIEHL	REL	
•				
	VE, QUAD, CHECK, HE			
. (CV 101)	/1021			
.FUNCTION:	LINE DOODELL SALT VANO	OF EDGIN WICH ATTAC	TO DEPOLATION (COOK THE	
		KS FRUM MIGRALING	TO REGULATORS (FROM THE	
	ANT TANK). DDE: FAILS CLGSED	(F)		
• RESTRICT		(17)		
• CAUSE(S):	IES FEUW.			
	ART STRUCTURAL FAILU	SE. MECHANICAL SHO	CV - ALCELEDATION.	
			SICN (D)CREW/VehICLL:	
	S OF REDUNDANCY - PAI			
			UR. (D) NO EFFECT.	
			GCCURS BEFCHE ET SEPARAT	1168
			T SEPARATION AND RESULT	
	CREW/VEHICLE.			
.CORRECTING				
	LOWDOWN MAY BE USED	AFTER SECOND FAILU	RE).	
.REMARKS/H				

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. MINIMUM DELTA CRACKING PRESSURE FOR CRACKING IS NECESSARY REQUIREMENT

TO MINIMIZE SYSTEM PRESSURE DROP TO TANKS.

SHUTTLE CRITICAL ITEMS LIST - DRBITER 102

FMEA NO 03-2F -101095-2 SUBSYSTEM : FWD - REACTION CONTROL CRIT. FUNC: 12 ABORT: .ASSEMBLY :PRESSURIZATION HDW: 3 CRIT. :HC284-0481-0001/-0002 -P/N RI MISSIONS: ΟF MZ HF VF X FF -P/N VENDOR: RS010500-001/-011 LC X DO X DO X LS PL PHASE(S): **DUANTITY** : 2 :ONE PER HELIUM SUPPLY REDUNDANCY SCREEN: A-PASS B-FAIL C-FAIL BYLINASAV DES POR THE S APPROVED .PREPARED BY: S S.* R BURKHART .DES Mail amen REL CE Daine REWIT R DIEHL .REL APPROVED WITH CHANGES See Section 13.0 .ITEM: VALVE, QUAD, CHECK, HE (CV 101/102) . FUNCTION: TO PRECLUDE PROPELLANT VAPORS FROM MIGRATING TO REGULATOPS (FROM THE PROPELLANT TANK). (F) .FAILURE MODE: FAILS CLOSED RESTRICTED FLOW. .CAUSE(S): PIECE PART STRUCTURAL FAILURE, MECHANICAL SHOCK, ACCELERATION. .EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE: (A) LOSS OF REDUNDANCY - PARALLEL PATH PROVIDES PRESSURANT FEED. (D) NC EFFECT. (B,C,) NO EFFECT UNLESS MULTIPLE FAILURES OCCUR. (E) FUNCTIONAL CRITICAL EFFECTS - IF FAILURE OCCURS BEFORE ET SEPARATION ·LOSS OF DOWN FIRING THRUSTERS WILL PREVENT ET SEPARATION AND RESULT IN

LOSS OF CREW/VEHICLE. .DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY: (A) VALVE SEAT MATERIAL WILL NOT STICK CAUSING A FAILURE TO CPEN AND SPECIFIED MAXIMUM CRACKING PRESSURE IS ONLY 5 PSI. (B) CHECK VALVE TO BE CERTIFIED FOR 100,000 CYCLES HITHOUT CHANGE IN PERFORMANCE CHARACTERISTICS/ALSO, WILL CHECK OUT EACH VALVE ELEMENT (PARALLEL -SERIES) AFTER EACH FLIGHT. VALVE SUBJECTED TO 48 MIN OF 10.6 GRMS RANDOM VIBRATION PER AXIS DURING QUAL PROGRAF. (C) AN AUDIT CONDUCTED ON 1-16-78 INDICATED THAT SUPPLIER OC VERIFIED RAW MATIL. CERTIFICATION TO SATISFY SHUTTLE DESIGN REQUIREMENTS, VERIFIED PROTECTION OF DETAIL PARTS FROM DAMAGE DURING MFG AND TEST, IN-PROCESS INSPECTION VERIFIED TURNAROUND INSPECTION TO INCLUDE MONITORING MFG TRAVELER SEQUENCES. FUNCTIONAL TESTS TO VERIFY FLOW AND CHECK FOR LEAKAGE. (D) NO FAILURE HISTORY. THIS IS A NEW DESIGN FOR SHUTTLE USE.

REV: 11/10/78

FMEA NUMBER SD75-SH-0016A SUBSYSTEM <u>Fwd</u> Reaction Control FAILURE MODE External Leakage ITEM Propellant Line Flex Assy. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY YES X I NO 1. ANNUNCIATE OR TAKE ACTION IN RESPONSE)?-IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD la. *YES USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF YES פוג* | גו IN-FLIGHT DETECTABILITY? 3. DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE N0 (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTMARE TO COMPENSATE FOR THIS 3a. X *YES l NO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. *YES X 1 110 INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT ***YES** NO OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW б. *0 | X ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. 7. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YES X NO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? IX I*NO B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? X *NO *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. NO H/S ISSUES 3. NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 6. RECOMMENDED CHANGES BELOW 2. X HARDWARE ACCEPTS RISK 4.

DETECTION DURING CHECKOUT IXIFMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: 1. V42P1115C, 1116C will give a class 2 alert once pressure drops to a pre-determined low. Gross leak indication occurs first. No redundancy available. V42P1116C and V42P1115C goes to shared meter M2 and will show a large pressure drop for worst case (large leak). FMEA Change - add V42P1116C to "failure detectable in flight".

HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-102106-1

ASSEMBLY : PROPELLANT FEED ABORT: CRIT. FUNC: 1 P./N RI : CRIT. HWD: 1 P./N VENDOR: MC271-GG95 MISSIONS: HF VF X FF CF SM QUANTITY : 2 PHASE(S): PL LO X OO X LO X LS .: GNE PER PROPELLANT NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE: C REDUNDANCY SCREEN: A-N/A B-N/A C-N/A FAILURE DETECTABLE IN FLIGHT?. YES TIME TO EFFECT: PROPELLANT TANK PRESSURE V42P-131CC AND MANIFOLD SECONDS TO DAYS PRESSURE 1312C61316C W676-421CC1 GROUND TUPNARGUND?YES MJ070-0001-C15 SAME AS FLIGHT INSTRUMEN TATION SD72-SH-G103-2 V87C-421CC1 PREPARED BY: APPROVED BY: DES J. TAGGART DES	SUPSYSTEM	:FWD - REACTION CONT	TROL FMEA NO	03-2F -1C2106-1	KEV:11/69/7
P/N VENDOR:MC271-C095 PHASE(S): PL LO X OO X DO X LS SOME PER PROPELLANT SOME PER PROPELLANT REDUNDANCY SCREEN: A-N/A B-N/A C-N/A FAILURE DETECTABLE IN FLIGHT? YES PROPELLANT TANK PRESSURE V42P-131CC AND MAMIFOLD PRESSURE 1312CG1316C SCOONDS TO DAYS PRESSURE 1312CG1316C PREPARED EY: JAJORO-0001-015 SAME AS FLIGHT INSTRUMEN TATION SD72-SH-0103-2 VS7C-421CC1 PREPARED EY: DES APPROVED EY: TO PROVIDE PROPELLANT FEED TO APPROPRIATE PROPELLANT FEEDLINES. FAILURE MODE: EXTERNAL LEAKAGE (S) CAUSE(S): MECHANICAL SHCCK, VIBRATION, FLOW, FATIGUE, IMPROPER INSTALLATION (WELD) EFFECT(S): ON (A) SUBSYSTEM (E) INTERFACES (C) MISSION (D) CREW/VEHICLE: (A) LOSS OF PROPELLANTS. (B) POTENTIAL CORROSION FROM HKÉE PROPELLANTS IN MCOULE. (C) POTENTIAL MISSION LOSS OR ABORT DECISION. (D) POTENTIAL LOSS OF CREW/VEHICLE IF FAILURE RESULTS IN LOSS OF ABORT DECISION.					
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FUNCTION REPORE ET SEPARATION.					
.CURRECTING ACTION:					
. ATTEMPT TO ISOLATE AND INITIATE ABORT IF REQ'D.			IATE ABORT IF R	EQ 'D.	
.REMARKS/HAZARDS:				~	
. PUTENTIAL HAZARD OF FIRE/EXPLOSION FROM FREE PROPELLANTS. SOME LEAK			PLOSION FROM FRI	EE PROPELLANTS. SU	IME LEAK
POINTS MAY NOT BE ISOLATABLE (I.E. BEFORE/UPSTREAM OF TANK ISOLATION					
VALVES) NO REDUNDANCY PROVIDED FUR LINES. SEE HAZARD NO. 1YXX-0302-04.	POINTS				

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

REV:11/09/78 SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -102106-1 1 .ASSEMBLY :PROPELLANT FEED ABORT: CRIT. FUNC: .P/N RI CRIT. HD#: VEX FF OF SM .P/N VENDOR: MC271-0095 MISSIONS: HF LO X OO X DO X LS .QUANTITY :2 PHASE(S): PL **CONE PER PROPELLANT** REDUNDANCY SCREEN: 4-N/A B-N/A C-N/A O: (A A A) YO GAYCAGGA MER .PREPARED BY: APPROVED SY: Lary Down DES -DES J. TAGGART RELOPE. E. Jaine -REL R DIEHL R = JABPROVED WITH CHANGES See Section 13.0 .ITEM: PROP LINE FLEX ASSY .FUNCTION: TO PROVIDE PROPELLANT FEED TO APPROPRIATE PROPELLANT FEEDLINES. .FAILURE MODE: EXTERNAL LEAKAGE (S) .CAUSE(S): MECHANICAL SHOCK, VIBRATION, FLOW, FATIGUE, IMPROPER INSTALLATION (MELD) .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CPEM/VEHICLE: (A) LOSS OF PROPELLANTS. (B) POTENTIAL CORRCSION FROM FREE PROPELLANTS IN HODULE. (C) POTENTIAL MISSION LOSS OR ABORT DECISION. (D) POTENTIAL LOSS OF CREW/VEHICLE IF FAILURE RESULTS IN LOSS OF RCS FUNCTION BEFORE ET SEPARATION. .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY: (A) STRUCTURAL MARGIN OF 2.0 WILL MINIMIZE FAILURE MODE POTENTIAL. PROOF TESTED TO 1.5 TIMES WORKING PRESSURE AND 65 MINUTES OF RANDOM VIERATION AT ANTICIPATED MISSION LEVELS. (C) IN PROCESS INSPECTIONS X-RAY OF WELDS & PENETRANT INSPECT. TURN AROUND INSPECTION INCLUDES MONITORING FUNCTIONAL TESTS DURING PRESSURIZATION CYCLE FOR EVIDENCE OF LEAKS AND DAMAGE. SUPPLIER INSPECTION DEEMED TO BE SATISFACTORY BASED ON SURVEY CONDUCTED ON 4-20-77. (D) NO FAILURE HISTORY FOR THIS SPECIFIC DESIGN.

	HARDWARE/SOFTWARE SUBSYSTEM _Fwd Reaction Control	ANALYSIS CHECKLIST FMEA NUMBER	03-2F-102108-1 SD75-SH-0016A
	ITEM Feedline and Fittings	FAILURE MODE Ext	
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (*ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	i.e., AUTOMATICALLY	YES X NO
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT TUSE TO DETECT THE FAILURE?	HE FLIGHT SOFTWARE COULD	*YES NO
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WIT IN-FLIGHT DETECTABILITY?	TH THE FMEA EVALUATION OF	YES 🗓 ™NO 🗌
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE E (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING		YES NO X
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE T FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION O PROGRAM LOGIC)?		*YES NO X
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE CINDUCE ANOTHER FAILURE?	OVERSTRESS THE HARDWARE C	OR *YES NO N
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE OTHER FUNCTIONS?	LOGIC, ADVERSELY AFFECT	*YES NO X
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANG	TOLERATE (CONSIDER CREW SE TO FMEA CRITICALITY.	*0 📉 *1 🗌 2
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILUR TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED		D N/A YESX10
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		•
!	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	•	YES X *NO
•	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/V	EHICLE?	YES X *NO
*EXF	LANATION REQUIRED (SEE BELOW)		
		· • • • • • • • • • • • • • • • • • • •	
	IGE/RETENTION RATIONALE SUMMARY	.`	
	☐ NO H/S ISSUES 3. ☐ NO SOFTWARE DE	TECTION 5. LIF	ACCEPTANCE RATIONALE BELOW
2.	X HARDWARE ACCEPTS RISK 4. DETECTION DURI	ING CHECKOUT 6. L.I.	RECOMMENDED CHANGES BELOW
	•	•	
	: ·	FMEA CHANGE RECOMM	1ENDED
-			
<u>E)</u>	PLANATION/COMMENTS:	•	
1. Gros	V42P1115C, 1116C will give a class 2 alert onc s leak indication occurs first.	e pressure drops to a	a pre-determined low.
6.	No redundancy available.		
7. wors	V42P1115C and V42P1116C goes to shared meter Mt case (large leak).	12 and will show a lan	rge pressure drop for

SUBSYSTEM	:FWC - REACTION	I CONTROL	FMEA	ND 03	-2F -	102138	6 - 1	KEV: 1	2/03/70
ASSEMELY	:PROPELLANT FEE	Đ.	A BOR T	•			CRIT.	Func:	1
P/N RI	:V070-421001						CRIT.	hWi.	1
P/N VENDOR	:		MISS	ONS:	HF	VF X	۴F	OF SI	v _j
QUANTITY	:1		PHASE	E(S):	PL	LO X	0G X	00 X L	S.
•	: ONE SET PER PE	ROPELLANT	NUMB E	R OF	SUCCE	SS PAT	THS KE	MAINI!	3
,	:		AFTER	FIRS	T FAI	LURE:			O
•		۶	REDUNDAN	ICY SC	REEN:	A-N.	/A B	-N/A	C-N/A
.FAILURE DE	TECTABLE IN FLI	GHT?. YES				TIME .	TO EFF	ECT:	
PROPELLANT	TANK PRESSURE	V42P-13100	AND MA	NIFOL	D .	SECON	DS TO	DAYS	
PRESSURE 1	312C	& 1316C			1	REFERI	ENCE D	ŪCUMEN	TS:
					,	V070~	421001		
GROUND TUR	NARGUND?	YES				MJ070-	-0001-	CLE	
SAME AS FL	ICHT INSTRUMEN	TATION					SH-010		
						VS70-	421001		
•									
•									
•	PREPARED BY	<i>(</i> :			APPR	OVED :	BY:		
•	DES	Α :	SIEGELI	VÍ		DES			
•	RE L		R DIEHI	_		REL			
•									

.ITEM: FEEDLINE AND FITTINGS

- . FROM TANK TO 1) TANK VALVES TO 2) MANIFOLD VALVES, TO 3) THRUSTERS. FUNCTION:
- TO PROVIDE FEED TO APPROPRIATE PROPELLANT COMPONENTS FOR THRUSTER OPERATION 3 AXIS ACCELERATION CONTROL AND ROTATIONAL CONTROL.
 •FAILURE MODE: EXTERNAL LEAKAGE (S)

.CAUSE(S):

- MECHANICAL SHOCK, VIBRATION/FATIGUE, STRUCTURAL FAILURE, IMPROPER INSTALLATION (WELD). FLUID FITTING SEAL FAILURE.
- .EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE:
- . (A) POTENTIAL LOSS OF PROPELLANTS. (B) POTENTIAL CORROSION FROM HAVE
- PROPELLANTS IN MODULE. (C) POTENTIAL MISSIUM LOSS OR AEGKT DECISION. (D) POTENTIAL LOSS OF CREW/VEHICLE IF LEAKING PROPELLANT EXPLODES DUE TO CONTACT WITH CATALYTIC AGENT OR HEAT SOURCE WITH SUBSEQUENT LOSS OF FORWARD MUDULE OR IF LOSS OF PROPELLANT PROHIBITS ET SEPARATION.
- .CCRRECTING ACTION:
- . ATTEMPT TO ISOLATE AND INITIATE ABORT IF REG O.
- .REMARKS/HAZARDS:
- . POTENTIAL HAZARD OF FIRE/EXPLOSION FROM FREE PROPELLANTS. SOME LEAK PCINTS MAY NOT BE ISOLATABLE (I.E. BEFORE/UPSTREAM OF TANK ISOLATION VALVES) NO REDUNDANCY PROVIDED FOR LINES. SEE HAZARD NO. 1YXX-53G2-04.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

FMEA NO 03-2F -102108-1 REV: 12/08/ SUBSYSTEM :FWD - REACTION CONTROL ASSEMBLY :PROPELLANT FEED. ABORT: CRIT. FUNC: 1 CRIT. -P/N RI :V070-421001 HDW: MISSIONS: YF X FF OF .P/N VENDOR: HF SM LO X CO X DO X LS **QUANTITY** PHASE(S): PL :1 ONE SET PER PROPELLANT REDUNDANCY SCREEN: A-N/A B-N/A C-N/ 14/19/BAPPROVED BY (NASA): APPROVED BY: ONT .PREPARED BY: SSM ر ر س .DES A SIEGELIN DES 12/15/78 REL .REL R DIEHL REL VOT? AAPRÖVED WITH CHANGES

.ITEM: FEEDLINE AND FITTINGS

- FROM TANK TO 1) TANK VALVES TO 2) MANIFOLD VALVES, TO 3) THRUSTERS.
 FUNCTION:
- . TO PROVIDE FEED TO APPROPRIATE PROPELLANT COMPONENTS FOR THRUSTER OPERATION 3 AXIS ACCELERATION CONTROL AND ROTATIONAL CONTROL.

 .FAILURE MODE: EXTERNAL LEAKAGE (S)

-CAUSE(S):

- . MECHANICAL SHOCK, VIBRATION/FATIGUE, STRUCTURAL FAILURE, IMPROPER INSTALLATION (WELD). FLUID FITTING SEAL FAILURE.
- .EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE:
- (A) POTENTIAL LOSS OF PROPELLANTS. (B) POTENTIAL CORPOSICN FROM FREE PROPELLANTS IN MODULE. (C) POTENTIAL MISSION LOSS OR ABORT DECISION. (D) POTENTIAL LOSS OF CREW/VEHICLE JF LEAKING PROPELLANT EXPLODES DUE TO CONTACT WITH CATALYTIC AGENT OR HEAT SOURCE WITH SUBSEQUENT LOSS OF FORWARD MODULE OR IF LOSS OF PROPELLANT PROHIBITS ET SEPARATION.

*DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY

(4) FACTOR OF SAFETY OF 4.0 WILL MINIMIZE FAILURE POTENTIAL. DYNATUBE FITTINGS HAVE DUAL SEALS. WELD CONSTRUCTION REDUCES JOINTS & POSSIBLE FASTENING CLAMPS AND TUBE BEND DESIGN ALLOWS DEGREE OF MOVEMENT WHICH HELPS PREVENTING LEAKS. (B) POST INSTALLATION TEST AND OPERATIONAL CHECKOUTS WILL VERIFY SYSTEM INTEGRITY. ALL LINES SUBJECTED TO PROOF TEST OF 1-25 X MAX OPERATING PRESSURE OR 1-1 X SURGE (TRANSIT) PRESSURE WHICHEVER IS GREATER. PERFORMED TUBING CERTIFICATION PER "ORBITER TUBING VERIFICATION PLAN SD75-SH-0205". (C) IN-PROCESS INSPECT INCLUDES NOT & CHECKS DURING INSTALLATION. TURNARCUND INSPECTION INCLUDES MONITORING FUNCTIONAL TESTS DURING PRESSURIZATION CYCLE FOR EVIDENCE OF LEAKS. VISUALLY INSPECT FOR DAMAGE WHERE ACCESSIBLE. HARDWARE INSPECTION IN ACCORDANCE WITH PLANNING RONTS APPROVED BY NASA (O) MINOR FAILURE HISTORY-CORROSION AND FAB PROBLEMS REPORTED DURING APOLLO PROGRAM AND CORRECTED WITH APPLICABLE TMO/TPC REQUIREMENT.

See Section 13.0

	HARDWARE/SOFTWARE SUBSYSTEM _ Fwd Reaction Control	ANALYSIS CHECKLIST FMEA NUMBER	03-2F-102120-1 SD75-SH-00016A
•	ITEMAC Motor Operated Valve (Tank)	FAILURE MODEFails	
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (1	.e., AUTONATICALLY	YES X NO
	ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	·	
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THUSE TO DETECT THE FAILURE?	IE FLIGHT SUFTWARE COUL	.D *YES NO
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH IN-FLIGHT DETECTABILITY?	H THE FMEA EVALUATION	OF YES X *HO
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EXCEITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING	FFECTS OF THE FAILURE G ALTERNATE PROGRAM LO	GIC)?
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO FAILURE MODE. (EITHER BY COMMANDING HARDWARE ACTION OF PROGRAM LOGIC)?	O COMPENSATE FOR THIS R IMPLEMENTING ALTERNA	*YES NO X
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OF INDUCE ANOTHER FAILURE?	VERSTRESS THE HARDWARE	OR *YES 110 X
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE IN OTHER FUNCTIONS?	LOGIC, ADVERSELY AFFEC	*YES NO X
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE	TOLERATE (CONSIDER CRE E TO FMEA CRITICALITY.	/ *0
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED	E MODE, ARE CUES PROVI CORRECTIVE ACTION?	DED N/A YESX HO
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		. •
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	-	YES X *NO
*FYP	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VE LANATION REQUIRED (SEE BELOW)	EHICLE? .	YES X *NO
<u> -</u> -			
	GE/RETENTION RATIONALE SUMMARY NO H/S ISSUES 3. NO SOFTWARE DE	TECTION E	ACCEPTANCE DATIONALE DELCE
*	☐ NO H/S ISSUES ☐ HARDWARE ACCEPTS RISK ☐ 4. ☐ DETECTION DURIN		RECOMMENDED CHANGES BELOW
	•		
	, .		
_		FMEA CHANGE RECO	MENDED
EX	PLANATION/COMMENTS:	· · · · · · · · · · · · · · · · · · ·	
1.	"RCS JETS" light on caution and warning panel.		
• •	right on educion and warning paller.	ı	

6. The manifolds are in parallel (2 legs) giving one redundant path.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS' - DRBITER 102

SUBSYSTEM	:FWU - REACTION CONTROL		
.4SSEMBLY	:PROPELLANT FEED	ABORT: ABORT,	CRIT. FUNC: 1R
.P/V RI	:MC284-C430-0007/-0008	RTIS	CAIT. hwb: 2
.P/W VENDOR	£:5750025/5750C26	MISSIONS: HF	VF X FF SF SM LO X OG X DO LS
YTITY AUG.	:4	PHASE(S): PL	LO X OG X DU LS
•	:TWO REQ!D PER PROP TANK	NUMBER OF SUCC	ESS PAINS REMAINING
•		AFTER FIRST FA	
_			: A-PASS F-PASS C-PAS:
FAILURE DE	TECTABLE IN FLIGHT?. YES		TIME TO EFFECT:
	HAMBER PRESS., MANIFOLD		
	2-1216, 1312- 1316, 1521-	-1522	REFERENCE DOCUMENTS:
• • • • • • • • • • • • • • • • • • • •	12 11.10, 1312 1310, 1321	1222	MJ07G-00C1-016
CONTRACT THE	NAROUND?YES		7672_CW_6162_^
SAME AS FL			S072-SH-0103-2 VS70-421601
2 KA BUNC	.16#1		V3 10-421661
•			
•		•	
•	MARK 1 P. T. V.		Photo I C Phi Ah
•	PREPARED BY:		RUVED BY:
•	DES R	GUNZALEZ	DES
•	REL	R DIEHL	REL
•			
•			
	, AC MOTOR OPERATED -		
	1/2"). (LV 161-164).		
.FUNCTION:			-
. I) PROV	IDES ISOLATION OF TANKS F	ROM MANIFOLDS. Z) PROVIDES BACK-UP
SHUT-OF!	F/ISOLATIUN OF PROP MAN1FO	CLDS AND ASSOCIAT	ED THRUSTERS!
COMPONE	NTS. EI-STABLE, (TANK PR	ESSURE-245 PS1).	AC MUTOR DRIVEN 3
PHASE (2 OF 3 WILL ACTUATE VALVE) 115 TO 200 VOLT	S 400 hZ*
	DDE: FAILS CLOSED		
	N - INCLUDES RESTRICTED F		DOES NOT ALLOW FROPER
MIXTURE			
.CAUSE(S):	1,7,120		
	GN, STRUCTURAL FAILURE.	PREMATURE POWER T	G MUTUR. ELECTRICAL
SHORT.	bis, or no or only in the control		
	ON (A) SUBSYSTEM (B) INTE	REACES (COMISSION	(n)cg=w/v5eT(1):
	S OF PROPELLANT FLOW IN T		
	R FUNCTION (THRUSTER BURN		
	E SURN-THRU PROPOGATION.		
	ENTIAL VEHICLE DAMAGE FRO		
			KENDEVGOS TAKSGETT
	ECOND FAILURE. CRIT I FOR	KILS ABORI+	
.CORKECTIN		man the country of the	U. 15010001 TE 15T
	REMAINING FORWARD THRUST		
	RS FOR BRAKING. DE-ORBIT	WITH APT MEDULES	
.REMARKS/H.			OCE OLDINAS TUBE
	AL HAZARD OF EXPLOSION IF	OX VALVE FAILS.	SEE PARKER FMEA & RMR
ちつちゅうクス			

SUBSYSTEM : FHO - REACTION CONTROL FMEA NO 03-2F -102120-1 REV:11/10/7 CRIT. FUNC: :PROPELLANT FEED ABORT: ABCRT, 18 .ASSEMBLY HDh: RTLS CRIT. 2 _P/N RI : MC284-0430-0007/-0008 HE Ũ۶ SM .P/N VENDOR:5750025/5750026 MISSIONS: VF X. FF LS _QUANTITY - 4 PHASE(S): PL LO X CO X DO THO REQ'D PER PROP TANK : C-PAS REDUNDANCY SCREEN: A-PASS B-PASS APPROVED/BY: APPROMED (NA SØ) _PREPARED BY: DES OST MINW FLER R GONZALEZ SSM DES. 2. E. Dames 1415/15 REY .REL R DIEHL REL <u>/ (ĉ/t)-</u> ARPROVED WITH CHANGES See Section 13.0

ITEM: VLV, AC MOTOR OPERATED TANK (1 1/2"). (LV 161-164).

.FUNCTION:

- 1) PROVIDES ISOLATION OF TANKS FROM MANIFOLDS. 2) PROVIDES SACK-UP SHUT-OFF/ISOLATION OF PROP MANIFOLDS AND ASSOCIATED THRUSTERS! COMPONENTS. 8I-STABLE, (TANK PRESSURE-245 PSI). AC MOTOR DRIVEN 3 PHASE (2 OF 3 WILL ACTUATE VALVE) 115 TO 200 VOLTS 400 HZ.
- .FAILURE HODE: FAILS CLOSED (F)
- POSITION INCLUDES RESTRICTED FLOW TO LEVEL THAT DOES NOT ALLOW PROPER MIXTURE RATIO.
- .CAUSE(S):
- . VIBRATION, STRUCTURAL FAILURE. PREMATURE POWER TO MOTOR, ELECTRICAL SHORT.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF PROPELLANT FLOW IN TWO MANIFOLDS AND SUBSEQUENT LOSS OF THRUSTER FUNCTION (THRUSTER BURN-THRU DUE TO OXID RICH MIXTURE). (B) POSSIBLE BURN-THRU PROPOGATION. (C) LOSS OF MISSION. ABORT DECISION. (D) POTENTIAL VEHICLE DAMAGE FROM COLLISION WITH RENDEVOUS TARGET. AFTER SECOND FAILURE. CRIT 1 FOR RTLS ABORT.
- -DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY:
- (A) VALVES ARE ALWAYS OPEN. DUAL SERIES SWITCHES WILL PPECLUDE SINGLE FAILURE PREMATURE ACTUATION. SHORTED RPC WILL NOT CLOSE VALVE. (B) EACH VALVE IS SUBJECTED TO ACCEPT TEST VIBRATION. VALVE IS SUBJECTED TO 48 MIN OR RAMDOM VIB IN EACH AXIS AT ANTICIPATED MISSION LEVELS AND AN ENDURANCE TEST EQUIV. TO 100 MISSIONS DURING THE QUAL TEST PROGRAM. EACH VALVE SUBJECTED TO PROOF PRESSUPE OF 1500 PSIG. MORE THAN 4 X WORKING PRESSURE. (C) AUDIT CONDUCTED 7-1-76 VERIFY SUPPLIER INSPECTION CONTROL OF PARTS 1D AND PROTECTION, MFG PROCESSES, ELECT TERMINATIONS. TURNAROUND INSPECTION INCLUDES MONITORING TEST TO VERIFY ELECTRICAL POWER TO VALVE FOR EVIDENCE OF SHORT CIRCUITY. (D) NO FLIGHT FAILURE EXPERIENCE.

	H SUBSYSTEM Fwd. Reaction Con	ARDWARE/SOFTWARE trol	ANALYSIS CHECK		03-2F-102150-1 SD75-SH-0016A	
	ITEM Quick Disconnect		FAILURE MODE Ex		eakage	
1.	DOES THE FLIGHT SOFTWARE DETECT TANNUNCIATE OR TAKE ACTION IN RESP	THIS FAILURE MODE (1	.e., AUTOMATICALL	.ү	YES X NO	
la.	IF NOT, DOES THE HARDWARE PROVIDE USE TO DETECT THE FAILURE?	•	HE FLIGHT SOFTWAR	E COULD	*YES NO	
2.	ARE THE ANSWERS TO QUESTIONS 1 AN IN-FLIGHT DETECTABILITY?	ID la CONSISTENT WIT	'H THE FMEA EVALUA	ATION OF	YES X +HO	
3.	DOES THE FLIGHT SOFTWARE TAKE ACT (EITHER BY COMMANDING HARDWARE AC	TION TO NEGATE THE E	FFECTS OF THE FAI	LURE VAM LOGIC)?	! YES NO X	
3a.	IF NOT, DOES THE CAPABILITY EXIST FAILURE MODE (EITHER BY COMMANDIN PROGRAM LOGIC)?				*YES	
4.	AS A RESULT OF THIS FAILURE MODE, INDUCE ANOTHER FAILURE?	. CAN THE SOFTWARE C	VERSTRESS THE HAR	IDWARE OR	*YES 110 X	
5.	CAN THIS FAILURE MODE, IN COMBINA OTHER FUNCTIONS?	TION WITH SOFTWARE	LOGIC, ADVERSELY	AFFECT	*YES NO X	
6.	HOW MANY OF THESE HARDWARE FAILUR ACTION AND HARDWARE/SOFTMARE OPER	RES CAN THE SHUTTLE MATION)? NOTE CHANG	TOLERATE (CONSIDE E TO FMEA CRITICA	R CREW	*0	
7.	IF CREW ACTION IS REQUIRED TO RES TO SIGNAL THE NEED FOR INTERVENTI	POND TO THIS FAILUR ON AND THE REQUIRED	E MODE, ARE CUES CORRECTIVE ACTIO	PROVIDED	N/A YESX HO	
8.	IF THE ANSWER TO EITHER 1 OR 3 IS	YES:				
	A. CAN THE BFS BE ENGAGED AFTER	OCCURRENCE?			YES XX *160	
	B. WILL BFS TOLERATE FAILURE WIT	HOUT LOSS OF CREW/V	EHICLE?		YES X *NO	
*EXP	LANATION REQUIRED (SEE BELOW)	•			LAS CALL	
CHAN	GE/RETENTION: RATIONALE SUMMARY					
1.[☐ NO H/S ISSUES 3	. 🔲 NO SOFTWARE DE	TECTION	5. ACCE	PTANCE RATIONALE BELOW	
2. [7	HARDWARE ACCEPTS RISK 4	. DETECTION DURI	NG CHECKOUT	6. RECO	MMENDED CHANGES BELOW	
	_	_		-		
	•					
			X FMEA CHANGE	DECOMMENDA		
_			[V]: LEW CHANGE	. ACCUPINENUI		
. <u>EX</u>	PLANATION/COMMENTS:		_	•		
1.	The tank pressure drop (wor	st case/full oner) will be dete	cted by V	42P1115C 1116C.	
un	 The tank pressure drop (worst case/full open) will be detected by V42P1115C, 1116C; unless regulated the gross leak indication will detect it. Also measurements 1313C, and 1314C appear obsolete and should be removed from the FMEA. 					
	The application and officers	_ 20 10m0104 110m				
	**					
				•		

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUCSYSTEM ASSEMBLY	:FWD -	REACTION	CONTROL						
.P/N RI				ABORT:					
.P/N VENDOR				MISSIONS	• 1.5	ue v	CRIT. 1	1WU:	1
•?JANTITY	• 4								
• 4 0 6 7 1 1 1				PHASE(S)					
		0.60 0.60	<u> የመመድር 1 4 አነም</u>	NUMBER OF	- 3000 C	COS PAI	HS KEMAI	INTING	
•	• HINCE	KEW PEK	PROPELLANT	ALIEK LT	(31 FA1	LLUXEF	5 m 41		1
• ENTINCE DE	T S C T A DI	E TN CLY	KEI Cuto vuc	DUNDANCY S	SCKEEN:	A-N/	A 5-N	/A C	-N/A
FUCK UE TA	LIEUIADL Ky does	E IN PLI	GHT?. YES V42P-1310C,			TIME I	O EFFECT	13	
12130 OF 12 12130 121	200 FRES	4C	V42PT151UL;	TTMA		SECOND	S TO DAY	15	_
1000 1110 1	7.00		1315C TANK						•
COUNTRY THE	LTOO IN AC CHINE		N/A				0001-015	_	
אטו שאטטיזפי	MAKCOM		* * * * * * * * Y A				H-0103-2	-	
•						42 IU-4	21001		
•									
•									
	PR≎	PARED BY	T		λυου	(OVED B	V *		
•	1 112	r=s	c sc.	ADIETT'	M: Liv	.04€2 B	; •		
•		REL	C 3C.	DIEHL		0 E J			
•			1	DICHE		NEL		······································	
•									
.ITEM: DISC	ONNECT.	QUICK.	FTLL	_					
			ED POPPET &	STRUCTURA	AL CAP	LMPTTY	-1261.		
· FUNCTION:			22 , 3, , 4, 4	011101010117		(11011)	1207.		
	DE FOR	DRAINING	, VENTING,	AND RIPED.	TNG PRO	PELLAN	T TANKS.	_ 1 N	
			TICAL VEHIC			,,,, ,,	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
			EAKAGE						
• DURING F				(3)	•				-
·CAUSE(S):									
	IN, AND	LOGSENIN	G OF RETAIN	ER NUT. P	TECE PA	RT STR	HCTUR 41	FATIBLE	< - ▲
MECHANIC				, , ,			COLONAL	, ,, ,, ,, ,,	· - 7
17.500.500.600		A							

- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- . (A) LOSS OF PROPELLANT OVERBOARD (1ST ORDER FAILURE FOR LUDSE RETAINING
- NUT). (B) POSSIBLE FIRE/EXPLOSION IF FUEL REACTS WITH GXIDIZER (2ND DRDER) OR EXTREME HEAT DURING RE-ENTRY. (C) POSSIBLE LOSS OF MISSIUM DUE TO FLUID LOSS. (C) POSSIBLE LOSS OF CREW/VEHICLE IF FAILURE OCCURS PRIOR TO ET SEPARATION.
- .CORRECTING ACTION:
- . INITIATE ABORT OR RESCUE OPERATIONS.
- *REMARKS/HAZARDS:
- POTENTIAL HAZARD FROM FIRE, EXPLUSION, AND FREE PROPELLANTS. SEE HAZARD 1YXX-0302-05.

SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -102150-1 REV:12/08/78 ASSEMBLY :PROPELLANT ABORT: CRIT. FUNC: -P/N RI :MC276-0018 CR IT. HDM: -P/N VENDOR:76301000 VF X FF OF HISSIONS: HF SM -QUANTITY :6 LO X OC X DO X LS PHASE(S): PL :THREE RED PER PROPELLANT REDUNDANCY SCREEN: A-N/A B-N/A C-N/A APPROVED BY MASAIR .PREPARED BY: APPROVED BY: C. Scorlett C SCARLETT .DES DES 4/15/16 Carl South .REL R DIEHL REL E. Dane R ÈL APPROVED WITH CHANGES See Section 13.0 .ITEH: DISCONNECT, GUICK, FILL PROPELLANT, SPRING LOADED POPPET & STRUCTURAL CAP (MD119-126). .FUNCTION: TO PROVIDE FOR DRAINING, VENTING, AND BLEEDING PROPELLANT TANKS. IN BOTH HORIZONTAL AND VERTICAL VEHICLE ORIENTATION. .FAILURE MODE: EXTERNAL LEAKAGE (5) DURING FLIGHT .CAUSE(S):

- VIBRATION, AND LOOSENING OF RETAINER NUT, PIECE PART STRUCTURAL FAILURE, MECHANICAL SHOCK.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF PROPELLANT OVERBOARD (1ST ORDER FAILURE FOR LCOSE RETAINING NUT). (B) POSSIBLE FIRE/EXPLOSION IF FUEL REACTS WITH OXIDIZER (2ND ORDER) OR EXTREME HEAT DURING RE—ENTRY. (C) POSSIBLE LOSS OF MISSION DUE TO FLUID LOSS. (D) POSSIBLE LOSS OF CREW/VEHICLE IF FAILURE OCCURS PRIOR TO ET SEPARATION.
- DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
- (A) CAP SEAL DESIGN DETERMINED TO BE ADEQUATE TO PRECLUDE LEAKAGE. DESIGN FACTOR OF SAFETY IS 3.0 X 710 PSIG MAX WORKING PRESSURE. CAP PLUS COUPLING CONSTITUTES DUAL SEALING. ALL RETAINER NUTS ARE PROPERLY TORQUED TO PRECLUDE LOOSENING. (B) SEALS ARE EXPOSED TO OVER 500 CYCLES DURING DEVELOPMENT. COJPLINGS ARE SUBJECTED TO 600 OPERATIONAL CYCLES IN OUAL TEST. ALL CAPS & COUPLINGS LEAK TESTED FOR 3 MIN. AT PRESSURES UP YO 1.25 MAX WORKING PRESSURE DURING ACCEPTANCE TEST. TURNAROUND LEAK CHECKS PERFORMED BEFORE EACH FLIGHT. RANDOM VIBRATION PERFORMED DURING QUAL PROGRAM. 68 MINUTES IN TWO EXES AT ANTICIPATED (C) TURNAROUND INSPECTION INCLUDES VISUAL INSPECTING MISSION LEVELS. ALL COUPLINGS THAT HAVE BEEN USED DURING TURNAROUND FOR DAMAGE PLUS INSPECTING FOR LEAKS DURING LEAK CHECKS. ALSO: PROPER BLEED SCREW TORQUE IS VERIFIED PRIOR TO REINSTALLATION OF ANY CAPS THAT HAVE BEEN REMOVED. SUPPLIER AUDIT COMDUCTED 4-5-77 VERIFIED THAT SUPPLIER INSPECTION CONTROLS RAW MATERIAL PARTS IDENTIFICATION, MFG PROCESSES, CONTAMINATION CONTROL, AND STORAGE ENVIRONMENTS. (D) NEW DESIGN FOR SHUTTLE APPLICATION. NO FLIGHT FAILURE HISTORY.

	SUBSYSTEM Fwd. Reaction C	HARDWARE/SOFTWARE ANAL ontrol _{EMFA}		03-2F-102150-2 SD75-SH-0016A
	ITEM Quick Disconnect			osed/Ground Ops
1.	DOES THE FLIGHT SOFTWARE DETECTATION OF THE RESERVE ANNUNCIATE OR TAKE ACTION IN RE	THIS FAILURE MODE (i.e., . SPONSE)?	AUTOHATICALLY	YES NO
la.	IF NOT, DOES THE HARDWARE PROVIUSE TO DETECT THE FAILURE?	DE INFORMATION THAT THE FL	GHT SOFTWARE COULD	*YES NO
2.	ARE THE ANSWERS TO OUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND la CONSISTENT WITH THE	FMEA EVALUATION OF	YES *NO
3.	DOES THE FLIGHT SOFTWARE TAKE A (EITHER BY COMMANDING HARDWARE	ACTION TO NEGATE THE EFFECT ACTION OR IMPLEMENTING ALT	S OF THE FAILURE ERNATE PROGRAM LOGIO	YES NO
3a.	IF NOT, DOES THE CAPABILITY EXT FAILURE MODE (EITHER BY COMMAND PROGRAM LOGIC)?			*YES NO NO
4.	AS A RESULT OF THIS FAILURE MODINDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE OVERST	RESS THE HARDWARE OF	R *YES NO
5.	CAN THIS FAILURE MODE, IN COMBIOTHER FUNCTIONS?	NATION WITH SOFTWARE LOGIC	, ADVERSELY AFFECT	*YES 110
6.	HOW MANY OF THESE HARDWARE FAIL ACTION AND HARDWARE/SOFTWARE OF	URES CAN THE SHUTTLE TOLER. PERATION)? NOTE CHANGE TO	ATE (CONSIDER CREW FMEA CRITICALITY.	*0
7.	IF CREW ACTION IS REQUIRED TO F TO SIGNAL THE NEED FOR INTERVEN	RESPOND TO THIS FAILURE MODE TTION AND THE REQUIRED CORRE	E, ARE CUES PROVIDER ECTIVE ACTION?	O N/A YES NO
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:		
	A. CAN THE BFS BE ENGAGED AFTE	R OCCURRENCE?		YES XNO
	B. WILL BFS TOLERATE FAILURE V	ITHOUT LOSS OF CREW/VEHICLE	:?	YES *NO
*EXP	LANATION REQUIRED (SEE BELOW)	·		<u></u>
. - -	GE/RETENTION RATIONALE SUMMARY			
	NO H/S ISSUES	3. NO SOFTWARE DETECTIV	ON E FT A	CCEDTANCE DATIONALE DELOU
		4. ☐ DETECTION DURING CH		
. <u></u> L	J TANDAMIC MODEL TO MICK	4. L. DETECTION BONTING CIT	C. [] N	CCOMMENDED CHARGES BEEOM
•			FMEA CHANGE RECOMME	ENDED
<u>E</u> X	PLANATION/COMMENTS:			
0u	t of scope - ground operation	ons only.		

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORSITER 102

```
FMEA NO 03-2F -102150-2
                                                               REV: 66/27/7.
SUBSYSTEM : FWD - REACTION CONTROL
                                     AEORT:
                                                          CRIT. FUNC:
.ASSEMBLY :PROPELLANT
                                                          CRIT. HWD:
*BIN SI
          :MC276-0018
                                                              U۴
.P/N VENDOR: 76201000
                                     MISSIONS: HF
                                                     VF X FF
.SUANTITY :6
                                     PHASE(S): PL X LO 00
                                     NUMBER OF SUCCESS PATHS REMAINING
           :THREE REO PER PROPELLANT AFTER FIRST FAILURE:
                                                                        Õ.
                                  REDUNDANCY SCREEN: A-PASS E-N/A
                                                                      C-PASS
.FAILURE DETECTABLE IN FLIGHT?. NA
                                                    TIMS TO EFFECT:
                                                    SECONUS TO HOURS
                                                    REFERENCE DOCUMENTS:
                                                    MJC70-0001-016
.GROUND TURNAROUND?.....YES
                                                    SD72-Sh-0103-2
.GROUND EQUIPMENT FLOW RATE READ OUT
                                                    VS70-4210C1
                                                APPROVED EY:
               PREPARED BY:
                                C SCARLETT
                    DE S
                                                     DES
                    REL
                                   R DIEHL
                                                     ŘĚL
.ITEM: DISCONNECT, QUICK, FILL
. PROPELLANT, SPRING LOADED POPPET & STRUCTURAL CAP (MO119-126).
.FUNCTION:
   TO PROVIDE FOR CRAINING, VENTING, AND BLEEDING PROPELLANT TANKS. IN
   SOTH HORIZONTAL AND VERTICAL VEHICLE OR IENTATION.
.FAILURE MODE: FAILS CLOSED
. CURING GROUND OPERATIONS
.C4USE(S):
   CUNTAMINATION, PIECE PART STRUCTURAL FAILURE IMPROPER HANDLING.
.EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES (C)MISSION (D) CREW/VEHICLE:
. (A) LOSS OF FILL CAPABILITY. (B) INCREASED GROUND OPERATIONS
                  (C) LAUNCH DELAY. (D) NONE.
   REQUIREMENTS.
.CCRRECTING ACTION:
. REMOVE AND REPLACE FILL VALVE OR ATTEMPT RECONNECTION.
.REMARKS/HAZARDS:
. MONE.
```

		-HARDWARE/SOFTWARE	ANALYSIS CHECKLIST	T 03-2F-1021	170-1	
	SUBSYSTEM <u>Fwd Reaction Con</u>	· ·=-		SD75-SH-00	016A	 -
	ITEM <u>DC Solenoid Operate</u> Vernier Inurster M	ed Valve anifold	FAILURE MODE _Fails	Closed - Pre	mature	Operation
1:	DOES THE FLIGHT SOFTWARE DETECT ANNUNCIATE OR TAKE ACTION IN RE	THIS FAILURE MODE (i	.e., AUTOMATICALLY	YES	Х ио	
la.	IF NOT, DOES THE HARDWARE PROVI USE TO DETECT THE FAILURE?	DE INFORMATION THAT T	HE FLIGHT SOFTWARE COU	ILD *YES	□ мо	
2.	ARE THE ANSWERS TO OUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND 1a CONSISTENT WIT	H THE FMEA EVALUATION	OF YES	∑ *80	
3.	DOES THE FLIGHT SOFTWARE TAKE A (EITHER BY COMMANDING HARDWARE	CTION TO NEGATÉ THE E ACTION OR IMPLEMENTIN	FFECTS OF THE FAILURE IG ALTERNATE PROGRAM LO	YES OGIC)?	□ №	
3a.	IF NOT, DOES THE CAPABILITY EXT FAILURE MODE (EITHER BY COMMAND PROGRAM LOGIC)?			*YES ATE	□ ио	X
4.	AS A RESULT OF THIS FAILURE MODINDUCE ANOTHER FAILURE?	E, CAN THE SOFTWARE O	VERSTRESS THE HARDWAR	E OR *YES	☐ NO	X
5.	CAN THIS FAILURE MODE, IN COMBIOTHER FUNCTIONS?	NATION WITH SOFTWARE	LOGIC, ADVERSELY AFFE	CT *YES	<u></u> Мо	
6.	HOW MANY OF THESE HARDWARE FAIL ACTION AND HARDWARE/SOFTWARE OP				*1X 2	
7.	IF CREW ACTION IS REQUIRED TO R TO SIGNAL THE NEED FOR INTERVEN			IDED N/A	YES X NO	
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES: .				-
	A. CAN THE BFS BE ENGAGED AFTE	R OCCURRENCE?		YES	∑ *N0	
	B. WILL BFS TOLERATE FAILURE W	ITHOUT LOSS OF CREW/V	EHICLE?	YES	X *NO	
*EXP	LANATION REQUIRED (SEE BELOW)					-
CHAN	GE/RETENTION RATIONALE SUMMARY					
	NO H/S ISSUES	3. NO SOFTWARE DE	TECTION 5.	ACCEPTANCE RA	TIONALE	BELOW
•] HARDWARE ACCEPTS RISK	=		RECOMMENDED C		
						e de la companya de l
		•	FMEA CHANGE RECO	OMMENDED		
-	PLANATION/COMMENTS:					
£Λ	FEAGATION COMMENTS:	•	•			Autom.
						Į
1. i	Manifold status on CRT and p	anel talk back is a	available.			
6. toler	One failure is all that can rate this failure since it is		e is no redundancy.	The Shuttle	e can	
7.	The measurements V42X1332X	and V42X1232X are	lownlisted and avai	lable for CRI	callur	· .

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM	:FWD - REACTION CONTROL	FMEA NO	03-2F -102	170-1	KeV: 12/	ō5/7.
	:PROPELLANT FEED					
	:MC284-6420-6011/-0012				1940 ៖	
P/N VENDOI	R:73995-0011/-0012	MISS 10NS	HF VF	X FF	OF 5M	_
SUARTITY			: FL LO			
	ONE REGID PER PROPELLAN	T NUMBER (OF SUCCESS	PATHS RE	MAINING	
,	:		RST FAILUR			0
•		REDUNDANCY				-FAI:
FAILURE DE	ETECTABLE IN FLIGHT?. YES	5	TIM	E TO EFF	ECT:	
	OSITN INDICATOR V42X1232E			CONDS		
V42X1332E			REF	ERENCE D	DOUMENTS	:
•) NJC	70-0001-	015	
GROUND TU	RNAROUND?YES	2	S Ð7	2-Sh-010	3-2	
SAME AS FI	LIGHT		VS7	0-421001		
•						
•			•			
•						
•	PREPARED EY:		APPROVE			
•	. DES R					
1	RE L	R DIEHL	٦Ē	:L		
•						
	E.DC SOLEN OPERATED -				25	
	THRUSTER MANIFOLD, (1/4)	1) 21-21 ABC	r, anrendir	1 DKIVCM	28 VUC •	
(LV 157	-158)					
FUNCTION:	TOO TOO ATTON OF SECTOR	N.T. M.A.N.T. CO		ra a meror excitor	382173	
	IDE ISCLATION OF PROPELLA					

- ACTIVATION.
- .FAILURE MODE: FAILS CLOSED-PREMATURE (F)
- GPERATION
- .CAUSE(S):
- IMPROPER ELECTRICAL SIGNAL (CONTINUOUS SHORT), PIECE PART FAILURE: CONTAMINATION, VIERATION.
- .FFFECT(S): UN (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF VERNIER THRUSTER FUNCTION. (B) NONE. (C) POSSIBLE EARLY
- MISSION TERMINATION. BECAUSE LARGE THRUSTERS INADEQUATE FOR SMALL RATE (D) NONE. ATTITUDE HOLD.
- .CORRECTING ACTION:
- ATTEMPT TO UTILIZE LARGE THRUSTER IN AFFECTED AXIS TO MAINTAIN SMALL DEADBAND.
- .REMARKS/HAZARDS:
- POTENTIAL FOR COLLISION WITH OR LOSS OF PAYLOAD/SATELLITE. SEE CONSOLICATED CONTROLS FMEA # 73895 FMEA 1.

ORIGINAL PAGE IS OF POOR QUALITY

SUBSYSTEM : FWO - REACTION CONTROL FMEA NG 03-2F -102170-1 REV:12/08/7 .ASSEMBLY :PROPELLANT FEED CRIT. FUNC: ABCRT: 2 .P/N RI :MC284-0420-0011/-0012 CRIT. HD#: 2 .P/N VENDGR:73895-C011/-0012 MISSICNS: VF X FF HF CF SM .QUANTITY : 2 PHASE(S): PL LO 00 X 00 LS ONE REGIO PER PROPELLANT : REDUNDANCY SCREEN: 2249-4 B-PASS C-FAI W. Ka .PREPARED BY: APPROVEDS BY: APPROVED (NASA) R BURKHART fister .DES DES SSH C. E Dasser 1415/18 . REL R DIEHL REL 191. Italizaret REL .ITEM: VLVE.DC SOLEN OPERATED -VERNIER THRUSTER MANIFOLD, (1/4") SI-STABLE, SCLENCID DOIYEN 28 VDC. (LV 157-158) .FUNCTION: TO PROVIDE ISOLATION OF PROPELLANT MANIFOLD AND ASSOCIATED VERNIER THRUSTERS 1) SUBSEQUENT TO COWNSTREAM FAILURE(S) 2) PRIOR TO SYSTEM ACTIVATION. .FAILURE MODE: FAIL CLOSED-PREMATURE (E) OPERATION .CAUSE(S): IMPROPER ELECTRICAL SIGNAL (CONTINUOUS SHORT), PIECE PART FAILURE, CONTAMINATION, VISPATION. .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CPEW/VEHICLE: (A) LCSS OF VERNIER THRUSTER FUNCTION. (3) YCME. (C) POSSIBLE EARLY MISSION TERMINATION. BECAUSE LARGE THRUSTERS INADEQUATE FOR SMALL RATE ATTITUCE HCLD. (D) NONE. DISPOSITION & RATIONALS (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY: (4) SERIES CONTROL CIRCUITRY PROVIDED TO MINIMIZE FAILURE MODE, 100 MICRON FILTER IS PROVIDED. MEDIA HAS BEEN FILTERED TO 25 MICRON PRICE TO ENTERING TANK. SPECIAL EMPHASAS PLACED ON THE DESIGN AND LAYOUT OF SCLENGID WIRING TO PRECLUDE SHORTS. (B) QUAL TEST INCLUDES 48 MINUTES PER AXIS OF RANDOM VIBRATION AT ANTICAPTED MISSION LEVELS AND LIFE TESTING CONSISTING OF 2000 CPERATING CYCLES. ITEM IS USED DURING SYSTEM EVALUATION AT WHITE SANDS TESTING. (C) TURNAPOUND INSPECTION INCLUDES MONITORING TESTS TO VERIFY ELECTRICAL POWER TO SCLENGIO VALVE FOR EVIDENCE OF SHORT CIRCUIT, SUPPLIER AUDIT CONDUCTED 8-31-77 VERIFIED SUPPLIE INSPECTION EXCERCISED CONTROL OF PARTS ID, PARTS PROTECTION, MFG PROCESSES, CONTAMINATION CONTROL, AND CORROSION PROTECTION VERIFICATION. (D) FAILURES ON APOLLO WERE MOSTLY DUE TO CONTAMINATION RESULTING FROM IN-HOUSE PROCESSING.

- HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-111110-1 SUBSYSTEM _ Fwd Reaction Control SD75-SH-0016A FMEA NUMBER Tank Assembly and Propellant FAILURE MODE Large Rupture Acquisition Device DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY 1. NO ANNUNCIATE OR TAKE ACTION IN RESPONSE)?. la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES USE TO DETECT THE FAILURE? ARE THE ANSWERS TO CUESTIONS I AND 1a CONSISTENT WITH THE FMEA EVALUATION OF 2. YES *110 IN-FLIGHT DETECTABILITY? 3. DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE NO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS 3a. *YES NO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. *YES NO INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT I NO ***YES** OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW 6. *0 |x | *1 | ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. 7. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YES X NO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? /*NO *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. NO H/S ISSUES 3. NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 2. K HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT 6. RECOMMENDED CHANGES BELOW In-Flight Detectability X FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: V42P1115C, 1116C will give a class 2 caution and warning alert. Gross leak indication will detect failure. If an internal rupture occurs and helium reaches the thrusters you will get a "fail off" light from redundancy management. There are no redundant tanks.

Backup flight system same as primary.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORSITER 102

			-11111C-1 REV:12/19/7:
	:PRCPELLANT FEED	AEORT:	CRIT. FUNC: 1
	:MC282-G061-0001/0002		CPIF. HWU: 1
	2:855C3320000-609/010		VF X FF OF SM
.QUANTITY			(LG X GO X DG X LS
	ONE REQ'D	NUMBER OF SUCC	ESS PATHS REMAINING
•	:PER PROPELLANT	AFTER FIRST FA	LURE: 0
•		REDUNDANCY SCREEN	: A-N/A P-N/A C-N/A
	ETECTABLE IN FLIGHT?. YES		TIME TO EFFECT:
.MCNITCR TA	NK PRESSURES V42P13100	,13120,13160,	SECONDS
.1116C	11,1		REFERENCE DOCUMENTS:
• • ,	1		MJ070-0001-01B
.GROU'VD TUR	NAROUND?YES	S	SD72-SH-0103-2
.SAME AS FL	.IGHT		VS70-421001
•	•		
•			
•			
•	PREPARED BY:	APP R SEMIS	RGVED 8Y:
•	DES	R BEMTS	DES
•	REL	R DIEHL	REL
-			
•			
.TIFM: TANK	C ASSY, PROPELLANT		
	NG PROPELLANT AUGUISITION	N DEVICE AND COMPA	RIMENT F785123 TIK
103).	O THE ELEMAN ACCOUNTS	T DEVICE AND COM A	ATTICLE OF THE
.FUNCTION:		•	
	E/SUPPLY PROPELLANT TO RE	FACTION CONTROL SN	CINE MANTERIOS.
	STORAGE PRESSURE 245 PS		
	DDE: STRUCTURAL FAILURE		ALCIT TACTORY.
	LL CRACK OR RUPTURE WHICH		3 TANK
.CAUSE(S):	TE CHACK ON KOLLOKE MITCH	I : NOT CORTES ANDON	D TRIN
	ON, OVERPRESSURIZATION, N	MECHANICAI CHUUN	STERCS PROCESSION.
FATIGUE.		RECHANICAL SHOCK,	217522 COUVO21914
	=	TATACTO ICLATESTON	CONC.) The Michael Con
	ON (A) SUESYSTEM (B) INTE		
	S OF PROPELLANT SUPPLY FO		
	PLOSION AND CERTAIN CONTA		
	MENT. (C) LOSS OF MISSIG		LUSS OF CREW/VEHICLE
	PLOSION AND/GR LACK OF PI	RUPELLANI.	
.CCRRECTING	•		
. NONE AV			
R EM AR KS/H		. 	
	AL HAZARO FROM FIRE, EXPI		FUEL IN MCLULE.
REFEREN	CE HAZARDS 1YXX-0302-02 /	AND 1YXX-0302-04.	

SUBSYSTEM :FWO - REACTION CONTROL FMEA NO 03-2F -111110-1 REV:11/09/ CRIT. FUNC: 1 .ASSEMBLY :PROPELLANT FEED ASORT: -P/N RI :MC282-0061-0001/0002 CRIT. HOR: -P/N VENOUR:855C3320000-009/010 MISSIONS: HE VEX FF OF SM .CUANTITY :2 PHASE(S): PL X LO X OO X DO X LS :ONE REQ'D :PER PROPELLANT REDUNDANCY SCREEN: A-N/A B-N/A C-N/: APPROVED BY:
DES PEL CEDALULIZATION APPROVED BY/ (NASA): .PREPARED BY: SSH W. Janonine •DES R BEMIS RED Jan Mary mut .REL R DIEHL APRROVED WITH CHANGES See Section 13.0 .ITEM: TANK ASSY, PROPELLANT INCLUDING PROPELLANT ACQUISITION DEVICE AND COMPARTMENT BARRIER. (TK 103). .FUNCTION: TO STORE/SUPPLY PROPELLANT TO REACTION CONTROL ENGINE MANIFOLDS. NOMINAL STORAGE PRESSURE 245 PSIG + OR -15 (1.5 SAFETY FACTOR). .FAILURE MODE: STRUCTURAL FAILURE -TANK WALL CRACK OR RUPTURE WHICH PROPOGATES ARCUND TANK .CAUSE(S): VIBRATION, OVERPRESSURIZATION, MECHANICAL SHOCK, STRESS CORROSION, FATIGUE. -EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE: (A) LOSS OF PROPELLANT SUPPLY FOR MODULE THRUSTERS. (9) POTENTIAL FIRE/EXPLOSION AND CERTAIN CONTAMINATION OF SUBSYSTEMS IM RCS COMPARTMENT. (C) LOSS OF MISSION. (D) POTENTIAL LOSS OF CREH/YEHICLE FROM EXPLOSION AND/OR LACK OF PROPELLANT. -DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY: (A) DESIGN FACTR OF SAFETY IS 1.5 MIN. DEVELOPMENT TESTS INCLUDE WELD CYCLE LIFE (800 CYCLES), FRACTURE MECHANICS, FORGING EVALUATION, AND TUBE SHAGING. (B) TANKS SUBJECTED TO RADIOGRAPHIC, FLUORESCENT PENETRANT, PROOF PRESSURE (1.33 MAX OPER PRESSURE), AND EXTERNAL LEAK TESTS DURING ACCEPTANCE TESTING. TANKS SUBJECTED TO 90 DAY PROPELLANT EXPOSURE: 800 PRESSURE CYCLES: 48 MINUTES PER AXIS OF 3.9 GRMS RANDOM VIBRATION AND BURST PRESSURE DURING QUAL PROGRAM. (C) TUPNAROUND INSPECTION INCLUDES MONITORING FUNCTIONAL TEST DURING PRESSURIZATION CYCLE FOR EVIDENCE OF LEAKS. VISUAL INSPECT WHERE ACCESSABLE FOR DAMAGE. AUDIT CONDUCTED 11-1-76 VERIFIED SUPPLIER INSPECTION CONTROL OF MATL IDENTIFICATION PARTS PROTECTION MFG PROCESSES, CORROSION PROTECTION

PROVISIONS: NDE EXAM OF HELDS AND STORAGE ENVIRONMENTS. (D) NONE (NEW

DEVELOPMENT ITEM).

	HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-111	110-2
	SUBSYSTEM Fwd Reaction Control FMEA NUMBER SD75-SH-0	016A
	ITEM <u>Tank Assembly and Propellant Acqui</u> sitioFAILURE MODE <u>Small Crack - Ext</u> — Device	ernal Leakage
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY YES ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	NO 🗆
là.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES USE TO DETECT THE FAILURE?	□ ио □
2.	ARE THE ANSWERS TO OUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF YES IN-FLIGHT DETECTABILITY?	★₩0 X
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	□ NO X
3 a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS *YES FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	<u> </u>
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR *YES INDUCE ANOTHER FAILURE?	☐ NO X
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT *YES OTHER FUNCTIONS?	NO X
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*1
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	YE2X 110
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? YES	
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? . YES	*NO
+	LANATION REQUIRED (SEE BELOW)	
CHAN	GE/RETENTION RATIONALE SUMMARY	• •
1.	NO H/S ISSUES	ATIONALE BELCK
2. X	☐ HARDWARE ACCEPTS RISK 4. ☐ DETECTION DURING CHECKOUT 6. ☐ RECOMMENDED	
		•
	In-Flight Detectability	
	In-Flight Detectability X FMEA CHANGE RECOMMENDED	
	DI AMATTON CONNECTE.	
	PLANATION/COMMENTS:	
Gross If ar	V42P1115C, 1116C will give a class 2 caution and warning alert. s leak indication will detect failure. n internal ruputre occurs and helium reaches the thursters you will get a "fa redundancy management.	il off" light
6.	There are no redundant tanks.	
8b.	Backup flight system same as primary.	

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - UNBITER 102

SUBSYSTEM : FWD - REACTION CON'	TROL FMEA NO 03-2F	-111110-2 REV	:12/18/7:
ASSEMBLY :PROPELLANT FEED	ABURT:	CRIF. FUN	C: 2
.P/N RI :MC282-0061-0001/60	02	CRIT. HA): 2
.P/N VENDOR: 25503320000-009/01	C MISSIONS: HF	VF X FF OF	SM
.QUANTITY :2		X LO X CO A CO A	
ONE REQ!D	NUMBER OF SUCC	ESS PATHS REMAIN	ING
PER PROPELLANT	AFTER FIRST FA	1LURE:	Û
	REDUNDANCY SCREEN		C-N/A
.FAILURE DETECTABLE IN FLIGHT?			
MONITOR TANK PRESSURE V42P		-	
.1116C		REFERENCE DOCUM	ENTS:
		MJ370-0001-01E	
GROUND TURNARGUND?	YES	SD72-SH-0103-2	
SAME AS FLIGHT AND VISU		V\$70-421601	
•			
•			
•			
. PREPARED PY:	APP	ROVED BY:	
. DES	R BEMIS	0 = S	
REL	R DIEHL	REL	
		, <u></u>	······
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.ITEM: TANK ASSY, PROPELLANT

- . INCLUSING PROPELLANT ACQUISITION DEVICE AND COMPARTMENT BARRIER. (IN 103).
- .FUNCTION:
- . TO STORE/SUPPLY PROPELLANT TO REACTION CONTROL ENGINE MANIFOLDS. NOMINAL STORAGE PRESSURE 245 PSIG + OR -15 (1.5 SAFETY FACTOR).
- .FAILURE MODE: EXTERNAL LEAKAGE (S)
- . TANK CRACK OR FLAW WHICH ALLOWS A LIMITED AMOUNT OF PROPELLANT TO LEAVE THE TANK.
- .CAUSE(S):
- . VIBRATION, STRESS CORROSIUN, PRESSURE CYCLES, FATIGUE OR FLANGE SHAL FAILURE.
- .EFFECT(S): ON (A) SUESYSTEM (B) INTERFACES (C) MISSION (D) CREW/VenICLE:
- . (A) LOSS OF A QUANTITY OF PROPELLANT AND HELIUM TO AN EXTENT DEPENDENT
- ON SIZEAND LOCATION OF LEAK. (B) CONTAMINATION OF SURRUUNDING AREA AND SUBSYSTEMS. (C) LOSS OF MISSION. (D) POTENTIAL EXPLOSION AND LOSS OF CREW/VEHICLE IF IGNITION SOURCE PRESENT (SECOND FAILURE).
- .CORMECTING ACTION:
- CLOSE HELIUM PRESSURIZATION ISOLATION VALVE TO MINIMIZE AMOUNT OF PROPELLANT/HELIUM LOST.
- .REMARKS/HAZARDS:
- POTENTIAL HAZARD FROM FREE PROPELLANT IN MODULE. NO REDUNDANCY PROVIDED FOR THIS ITEM. REFERENCE HAZARD 1YXX-0302-05.



SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -1111110-2 REV: 11/10/79 .ASSEMBLY :PROPELLANT FEED ABORT: CRIT. FUNC: 2 :MC282-0061-0001/0002 •P/N RI CRIT. 2 HD#: -P/N VENDOR:855C3320000-009/010 ΗF VF X FF MISSIONS: - QUANTITY **\$2** PHASE(S): PL X LO X CO X DO X LS :ONE REQ! D **:PER PROPELLANT** REDUNDANCY SCREEN: A-N/A B-N/4 C-N/A .PREPARED BY: AP PROVED BY: (NASA): APPROVED BY/ .DES المراجع المراجع R BEMIS DES C. E. Janes . REL R DIEHL REL R. ED APPROVED WITH CHANGES

.ITEM: TANK ASSY, PROPELLANT

 INCLUDING PROPELLANT ACQUISITION DEVICE AND COMPARTMENT BARRIER. (TK 103).

.FUNCTION:

- TO STORE/SUPPLY PROPELLANT TO REACTION CONTROL ENGINE MANIFOLDS. NOMINA STORAGE PRESSURE 245 PSIG + OR −15 (1.5 SAFETY FACTOR).
- -FAILURE HODE: EXTERNAL LEAKAGE (S)
- TANK CRACK OR FLAW WHICH ALLOWS A LIMITED AMOUNT OF PROPELLANT TO LEAVE THE TANK.

.CAUSE(S):

- VIBRATION, STRESS CORROSION, PRESSURE CYCLES, FATIGUE OR FLANGE SEAL FAILURE,
- EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF A QUANTITY OF PROPELLANT AND HELIUM TO AN EXTENT DEPENDENT ON SIZEAND LOCATION OF LEAK. (B) CONTAMINATION OF SURROUNDING AREA AND SUBSYSTEMS. (C) LOSS OF MISSION. (D) POTENTIAL EXPLOSION AND LOSS OF CREW/VEHICLE IF IGNITION SOURCE PRESENT (SECOND FAILURE).
- -DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C) INSPECTION (D) FAILURE HISTORY:
- (A) DESIGN FACTR OF SAFETY IS 1.5 MIN. DEVELOPMENT TESTS INCLUDE WELD CYCLE LIFE (800 CYCLES). FRACTURE METHANICS, FORGING EVALUATION, AND TUBE SWAGING. (B) TANKS SUBJECTED TO RADIOGRAPHIC, FLUGRESCENT PENETRANT, PROOF PRESSURE (1.33 HAX OPER PRESSURE), AND EXTERNAL LEAK TESTS DURING ACCEPTANCE TESTING. TANKS SUBJECTED TO 90 DAY PROPELLANT EXPOSURE, 800 PRESSURE CYCLES, 48 MINUTES PER AXIS OF 3.9 GRMS RANDOM VIBRATION AND BURST PRESSURE DURING QUAL PROGRAM. (C) TURNAROUND INSPECTION INCLUDES MONITORING FUNCTIONAL TEST DURING PRESSURIZATION CYCLE FOR EVIDENCE OF LEAKS. VISUAL INSPECT WHERE ACCESSABLE FOR DAMAGE. AUDIT CONDUCTED 11-1-76 VERIFIED SUPPLIER INSPECTION CONTROL OF MATL IDENTIFICATION PARTS PROTECTION MFG PROCESSES, CORROSION PROTECTION PROVISIONS, NOE EXAM OF WELDS AND STORAGE ENVIRONMENTS. (D) NONE (NEW DEVELOPMENT ITEM).

See Section 13.0

HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-111110-3 SUBSYSTEM Fwd. Reaction Control FMEA NUMBER SD75-SH-0016A FAILURE MODE __ Restricted Flow ITEM Tank Assembly and Propellant Acquisition Device 1. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY Jy[ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD *YES NO USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO OUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY? DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE З. X I (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPALILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS 3a. *YES NO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. X *YES NO INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS? 6. HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW *0 | X *1 | 2 ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. N/A YES X NO TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? 8. IF THE ANSWER TO EITHER 1 OR 3 IS YES: CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 1. NO H/S ISSUES 3. M NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELOW 6. RECOMMENDED CHANGES BELOW 2. X HARDWARE ACCEPTS RISK 4.

DETECTION DURING CHECKOUT FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: "Fail Off" detection in RCS RM. 1. 6. No redundant tanks. _7.__No _correcting_action___abort._. 8b. Same as primary.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

.ASSEMBLY .P/N RI .P/N VENDOR .OUANTITY	:PROPELLANT FEED :MC282-0061-0001/00 !:855C3320C0C-0C9/01	AEORT: 302 LC MISSIONS: PHASE(S): NUMBER OF AFTER FIR	3-2F -111110-3 REV CRIT. FUT CRIT. HE HE VEX FE UF PL LOX UOX DOX SUCCESS PATHS REMAINS ST FAILURE:	NC: 1 VC: I SM V LS VING
	ETECTABLE IN FLIGHT: FURMANCE	REDUNDANCY S	CREEN: A-N/A E-N/A TIME TO EFFECT: SECONDS TO DAY: REFERENCE DOCUM MJ070-C001-C18	: S
GROUND TUR	RNARGUND?	•••NÜ	SD72-SH-C163-2 VS70-4210C1	
• •	PREPARED BY: DES REL	R BEMIS R DIEHL	APPROVED EY: DES	
. INCLUDING 103) FUNCTION: . TO STORE	E/SUPPLY PROPELLANT	SITION DEVICE AND TO REACTION CONTR	COMPARTMENT SARKIER. OL ENGINE MANIFOLDS.	(TK
.FAILURE MO	DDE: RESTRICTED FL	(S) - WC ELLANT ACQUISITION	DEVICE WHICH BLOCKS	UR
VIBRATION THRUST IN THRUST	STER MANIFOLD. (SE : ON (A)SUBSYSTEM (I S OF FULL PROPELLAN S OF MISSION DUE TO WHEN MCDULE REQUIRE	E FAILUKE MODE NO. B)INTEKFACES (C)MI T FLOW CAPABILITY/ LOSS OF PROPELLAN	SSION (D)CREW/VEHICE HELIUM INGESTION. (T. (D) NOWE UNLESS	ė: b) NONe.
.REMARKS/H	ATLABLE - CLOSE DOW AZARDS:		ISSIGN. TITUDE CONTROL MUST	υĒ

ORIGINAL PAGE IS OF POOR QUALITY

ACCOMPLISHED BY ARCS.

FHEA NO 03-2F -111110-3 REV: 11/10/78 SUBSYSTEM : FWD - REACTION CONTROL CRIT. FUNC: ABORT: -ASSEMBLY :PROPELLANT FEED HDW: :MC282-0061-0001/0002 CRIT. -P/N RI SM HF VF X FF OF MISSIONS: P/N VENDOR:855C3320000-009/010 LO X DO X DO X LS PL PHASE(S): _DUANTITY : ONE REQID :PER PROPELLANT C-N/4 REDUNDANCY SCREEN: $\Delta \setminus M - \Delta$ B-N/A BY (NASA) APPROVED .PREPARED BY: APPROVED, BY: SSM R BEMIS DES .DES भूगाँडीने ह : Danne REL -REL R DIEHL PPROVED WITH CHANGES See Section 13.0

.ITEM: TANK ASSY, PROPELLANT

INCLUDING PROPELLANT ACQUISITION DEVICE AND COMPARTMENT BARPIER. (TK 103}.

. FUNCTION:

APINON TO STORE/SUPPLY PROPELLANT TO REACTION CONTROL ENGINE MANIFOLDS. STORAGE PRESSURE 245 PSIG + OR -15 (1.5 SAFETY FACTOR).

.FAILURE MODE: RESTRICTED FLOW -(2)

- STRUCTURAL FAILURE OF PROPELLANT ACQUISITION DEVICE WHICH BLOCKS OR RETARDS RATE OF FLOW OF PROPELLANT INTO TANK OUTLET. .CAUSE(S):
- VIBRATION, MECHANICAL SHOCK, EXCESSIVE FLOW RATES DUE TO EXCESSIVE GAS (SEE FAILURE MODE NO. 4 ON NEXT PAGE). IN THRUSTER MANIFOLD.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF FULL PROPELLANT FLOW CAPABILITY/HELIUM INGESTION. (B) NOME. (C) LOSS OF MISSION DUE TO LOSS OF PROPELLANT. (D) NONE UNLESS FAILURE OCCURS WHEN MODULE REQUIRED FOR ET SEPARATION.
- .DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY:
- (A) 1.5 DESIGN SAFETY FACTOR. DEVELOPMENT TESTS VERIFY WELD CYCLE LIFE, SCREEN REPAIR METHOD. SCREEN CYCLE LIFE AND SCREEN FLOW. (B) PROPELLANT ACQUISITION DEVICE COMPONENTS. SUBASSEMBLIES AND TANK ASSY INTEGRITY TANKS SUBJECTED TO PROPELLANT VERIFIED BY PERFORMING BUBBLE POINT TEST. EXPOSURE, 200 EXPULSION CYCLES, 48 MINUTES PER AXIS OF 3.9 GRMS RANDOM (C) TURNAROUND VIBRATION AND BURST PRESSURE DURING QUAL PROGRAM. AUDIT CONDUCTER INSPECT INCLUDES MONITOR FLOW DURING FUNCTIONAL TESTS. 11-1-76 VERIFIED SUPPLIER INSPECTION CONTROL OF MATE IDENTIFICATION PARTS PROTECTION MFG PROCESSES, CORROSION PROTECTION PROVISIONS, NDE EXAM OF HELDS AND, STORAGE ENVIRONMENTS.

-HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-111110-4 SUBSYSTEM _Fwd Reaction Control FMEA NUMBER SD75-SH-0016A ITEM Tank Assembly and Propellant Acquisition FAILURE MODE Loss of Gas in Propellant Device Acquisition Device DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY 1. YES X NO ANNUNCIATE OR TAKE ACTION IN RESPONSE)? la. IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD ΓX *YES МО USE TO DETECT THE FAILURE? ARE THE ANSWERS TO QUESTIONS I AND 1a CONSISTENT WITH THE FMEA.EVALUATION OF 2. **1 ***N0 IN-FLIGHT DETECTABILITY? 3. DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE X YES NO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS 3a. *YES I NO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. *YES 110 ГХ INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT ГХ *YES 1 NO OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW 6. ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED 7. N/A | YES NOX TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: 8. A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? X | *k0 B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE? *NO *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETENTION RATIONALE SUMMARY 5. ACCEPTANCE RATIONALE BELOW 1. _ NO H/S ISSUES -3. NO SOFTWARE DETECTION 6. RECOMMENDED CHANGES BELOW 2. X HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT X FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: "Fail Off" detection in RCS RM. ٦. 6. No redundant tanks. No correcting action - abort. 8. Same as primary.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - URBITER 102

			5-25 -111110-4	
	PROPELLANT FEED	ABCRT:		. FUNL: 2
	:MC282-CC61-G0C1/0002			. HAU: 2
	R: 855C332000C-009/016	MISSIONS:	HF VF X FF	OF SM
YTIT/AUG.	:2	PHASE(S):	PL X LC X dc X	D0 X ES
•	GNE REQ D	on NUMBER OF	SUCCESS PATES R	EMAINING
•	PER PROPELLANT	AFTER FIRS	PL X LE X de X SUCCESS PATHS R ST FAILURE:	C
•		VEDONDANCE SC	ACEEMA KIMAN	5-147 W C-147 W
	ETECTABLE IN FLIGHT?. YES		TIME TO EF	FECT:
• ENGINE PE	RECRMANCE AND C HAMBER PR	ESSURE.V42P15		1 3 3 5 4 4 1 7 1 2 3 4 1 .
•			REFERENCE	
			MJ070-5901	
•GROUND TUR	RNAROUND?NO		SD72-SH-01	
•			V\$70-421CG	1
•				
•				
•				
•	PREPARED EY:		:Yd CEVUARA	
•	DE S	R BEMIS	0r\$	
•	REL	R DIEHL	Rel	
•				
	K ASSY, PROPELLANT			
	NG PROPELLANT ACQUISITION	DEVICE AND C	COMPARTMENT BARK	IEK. (TK
103).				
.FUNCTION:				
	E/SUPPLY PROPELLANT TO RE			
	STORAGE PRESSURE 245 PSI		1.5 SAFETY FACTO	R).
	OUE: LOSS OF GAS RETENTI			
	ANT ACCUISITION DEVICE (P	AL).		
.CAUSE(S):	a) augus and augus augus augus	T		• •
	CN, SHOCK, PROPELLANT CON			
	: ON (A) SUBSYSTEM (B) INTE			
	ESSIVE GAS FLOW TO THRUST			
	ENTIAL DAMAGE TO THRUSTER		-	
	SIBLE LOSS OF CREW/VEHICL	E IF FAILURE	UCCURS PRIGR TO	LI
SEPARAT				
.CCRRECTIN				
	WN FRCS AND ABORT MISSION	•		
-REMARKS/H				
	TECTED, THE THRUSTERS COU	LD BE DAMAGEL	D MHICH COULD CA	OSE ENTRY
UNCERTA	INIY.			

FMEA NO 03-2F -1111110-4

REV:11/10/

SUBSYSTEM : FWD - REACTION CONTROL ABCRT: CPIT. FUNC: .ASSEMBLY :PROPELLANT FEED 2 P/N RI :MC282-0061-0001/0002 CR IT . HUr : 2 .P/N VENDOR:855C3320000-009/010 **MISSIONS:** HF VF X FF ٦£ SM PHASE(S): PL X LO X CO X DO X LS .QUANTITY :2 : ONE REQ'D #PER PROPELLANT REDUNDANCY SCREEN: A-N/A B-N/A (NA 弘): /) APPROVED BY: APPROYED -.PREPARED BY: R SEMIS S5.4 -DES DES RED . REL R DIEHL REL APPROVED WITH CHANGES See Section 13.0 .ITEM: TANK ASSY, PROPELLANT INCLUDING PROPELLANT ACQUISITION DEVICE AND COMPARTMENT PARRIER. (TK 1031. .FUNCTION: TO STORE/SUPPLY PROPELLANT TO REACTION CONTROL ENGINE MANIFOLDS. NOMINA STORAGE PRESSURE 245 PSIG + OR -15 (1.5 SAFETY FACTOR). .FAILURE MODE: LOSS OF GAS RETENTION IN PROPELLANT ACQUISITION DEVICE (PAD). -CAUSE(S): VIBRATION. SHOCK: PROPELLANT CONTAMINATION (CHEMICAL CR DIRT). .EFFECT(S): JN (A)SUBSYSTEM (B)[NTERFACES (C).MISSION (D)CREW/VEHICLE: (A) EXCESSIVE GAS FLOW TO THRUSTERS COULD CAUSE TANK BARRIER FAILURE. (3) POTENTIAL DAMAGE TO THRUSTERS IF UNDETECTED. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE IF FAILURE OCCURS PRIOR TO ET SEPARATION. .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY: (A) DESIGN FACTR OF SAFETY IS 1.5 MIN. DEVELOPMENT TESTS INCLUDE WELD CYCLE LI FE (800 CYCLES), FRACTURE MECHANICS, FORGING EVALUATION, AND TUBE SWAGING. (8) PROPELLANT ACQUISITION DEVICE COMPONENTS. SUBASSEMLIES AND TANK ASSY INTEGRITY VERIFIED BY PERFORMING BUBBLE POINT TESTS. TANKS SUBJECTED TO PROPELLANT EXPOSURE, 200 EXPULSION CYCLES, 48 MINUTES PER AXIS OF 3.9 GRMS RANDOM VIBRATION AND BURST PRESSUR DUPING QUAL PROGRAM. (C1 TURNAROUND INSPECTION INCLUDES PERIODIC BUBBLE POINT CHECKS OF THE PAD. AUDIT CONDUCTED II-1-76 VERIFIED SUPPLIER INSPECTION CONTROL OF MATE IDENTIFICATION PARTS PROTECTION MFG PROCESSES, CORROSION PROTECTION PROVISIONS, NOE EXAM OF WELDS AND STORAGE ENVIRONMENTS. (D) NONE (NEW DEVELOPMENT ITEM).

		HARDWARE/SOFTWAR		UJ	-2F-121308-1	
	SUBSYSTEM <u>Fwd Reaction Cor</u>		FMEA NUMBER			
	ITEM Flex Line and Fitir	igs	FAILURE MODE	External	<u>Leakage</u>	
1.	DOES THE FLIGHT SOFTWARE DETECT ANNUNCIATE OR TAKE ACTION IN RES	THIS FAILURE MODE ((i.e., AUTOMATICAL	LY	YES X NO	
lā.	IF NOT, DOES THE HARDWARE PROVIDUSE TO DETECT THE FAILURE?	E INFORMATION THAT	THE FLIGHT SOFTWAR	RE COULD	*YES ☐ NO	
2.	ARE THE AMSWERS TO QUESTIONS 1 / IN-FLIGHT DETECTABILITY? -	AND la CONSISTENT WI	TH THE FMEA EVALUA	ATION OF	YES X *NO	
3.	DOES THE FLIGHT SOFTWARE TAKE AS (EITHER BY COMMANDING HARDWARE A	CTION TO NEGATE THE ACTION OR IMPLEMENT	EFFECTS OF THE FA	ILURE RAM LOGIC)?	YES \ \ \ NO	
3a.	IF NOT, DOES THE CAPABILITY EXISTALLURE MODE (EITHER BY COMMAND PROGRAM LOGIC)?	ST FOR THE SOFTWARE ING HARDWARE ACTION	TO COMPENSATE FOR OR IMPLEMENTING AN	THIS LTERHATE	*YES NO	X)
4.	AS A RESULT OF THIS FAILURE MODI INDUCE ANOTHER FAILURE?	E, CAN THE SOFTWARE	OVERSTRESS THE HAI	RDWARE OR	*YES NO	
5.	CAN THIS FAILURE MODE, IN COMBINOTHER FUNCTIONS?	NATION WITH SOFTWARE	E LOGIC, ADVERSELY	AFFECT	*YES NO	X
6.	HOW MANY OF THESE HARDWARE FAILU ACTION AND HARDWARE/SOFTWARE OP	URES CAN THE SHUTTLE ERATION)? NOTE CHAN	TOLERATE (CONSIDE IGE TO FMEA CRITICA	ER CREW ALITY.	*0 *1	
7.	IF CREW ACTION IS REQUIRED TO RITO SIGNAL THE NEED FOR INTERVEN	ESPOND TO THIS FAILUTION AND THE REQUIRE	JRE MODE, ARE CUES ED CORRECTIVE ACTI	PROVIDED GN?	N/A ∏YES\\\	0[]
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:				
	A. CAN THE BFS BE ENGAGED AFTER			•.	YES X *NO	
	B. WILL BES TOLERATE FAILURE W	ITHOUT LOSS OF CREW,	VEHICLE?	•	YES X *NO	
*EXF	LANATION REQUIRED (SEE BELOW)					
	GE/RETENTION RATIONALE SUMMARY					
		3. \(\sum \) NO SOFTWARE I				
2.	X) HARDWARE ACCEPTS RISK	4. DETECTION DU	RING CHECKOUI	6. LI RECU	MMENUEU CHANGES	RELÓM
	•		FMEA CHANG	E RECOMMEND	ED	
 	PLANATION/COMMENTS:					
<u> </u>	reprint tony confidence.					
1.	V42P1115C, 1116C will give	class 2 alarm.				
G~	oss leak detection applies.					
ur	uss reak detection appries.					

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - GREITER 102

SUESYSTEM	:FWD - REACTION CO			3-2F -121308		
. A SSEMELY			ABORT:			1
	:MC271-GG84.				CKIT. HWU:	1
*P/N VENDUR	174713-THRU 74717					
•QUANTIFY			PHASE(S):	PL X LO X	UG X DG X LS A	
•	ONE FUEL AND ONE	OXIDIZ.				
•	: PER THRUSTER			ST FAILURE:		2
* * * * * * * * * * * * * * * * * * * *	**************************************	KE	DONDANCY SO	CREEN: A-NA	'A B-N/A C-	AV
*FPILUKE DE	PRESSURE V#? RNARGUND?	AF2		TIME	O LFFECT:	
• A NIPOLD 1	KE220KE AT!			SECONI	S TO DAYS	
•	•	•		ドナナナス	ACE DOCUMENTS:	
• CECHNO THE	S A A D ESTAND O	VEC		MJ /0-(0001-018	
**************************************	KNAKUUNU (••••YES		SD 72-5	5 5- 6163-2	
• VIOUAL INC	SECLICA			A2 \0-+	+21CG1	
•						
•						
•	PREPARED BY:			100000000		
•			AGGART	APPROVED 5	3 Y I	
•	DES REL	J. i	AGGARI	DES	*************************	
•	KEL	ĸ	DIEHL	REL		
•						
TTEMP LINE	ASSEM., FLEXIBLE					
. AND FITT	•					
.FUNCTION:	11963.					
	IDE COUPLING BETWEE	N BOGBEL	INT CHECU	CTEM AND EN	SUARD OCC	
	AND VERNIER THRUST		LANT SUBSIL	SIEM AND FUR	WARE KCS	
	DE: EXTERNAL LEAK		153	,		
	OF LINE OR COUPLIN		(3)			
.CAUSE(S):	CA ETHE OK OCOLETA	•••				
	, SHOCK, VIBRATION,	. HAMDI TM	2			
	ON (A) SUBSYSTEM			ירטומז ומוזא	DE MENTEL	
. (4) 1059	OF PROPELLANTS TO	I FXTCNT	THE LEAK ST	VE - (R) INC	.A/ VERTOLE.	
	& USE OF ALTERNATE					f. at
PRIGR TO	J PLANNED TIME. (NO FEE	HOT AFTER A	PERMIT THEORY	(C) #8K (C)	1224
EXCESSIV	E & RESULTS IN IGN	TTION WE	TH BEACLANT	T (SNC ORCES	CATILDAL FOLDT	h.f
A RTIS A	ABORT THE LOSS UF A	MANIFER	77 NEACTAN	IN THE LOSS	CIFICAL CORT	11.6
FIRING T	THRUSTERS WHICH RES	INT THE	DRIT I. PI	IRITME ASCENT	THE ENTITIES	
	BE DETECTED AND ISC					
VEHICLE.		JERTED MI	TON RESOLT	2 14 1033131	.c 2005 Gr	
.CCRRECTING	=					
	THRUSTER AT MANIFO	i D.				
.REMARKS/H						
	AL HAZARD FROM FREE	E FUEL IN	MODULE.			

ORIGINAL PAGE IS OF POOR QUALITY

FMEA NO 03-2F -121308-1 REV: 11/10/ SUBSYSTEM : FWD - REACTION CONTROL .ASSEMBLY :THRUSTER CRIT. FUNC: ASCRT: CRIT. HD#: :MC271-0084 P/N RI HF .P/N VENDOR:74713-THRU 74717 *SYNOISSIM M2 X FF JF X SM PL X LO X OO X CO X LS X PHASE(S): DE: YTITMAUQ. : ONE FUEL AND ONE OXIDIZ. :PER THRUSTER REDUNDANCY SCREEN: 4-N/A $A \setminus M - 3$ APPROVED BY (NABA): .PREPARED BY: AP PATTY ED . 8Y: DESTINE PROPERTY OF STATES .DES J. TAGGART SSM प हैं। .REL R DIEHL APPROVED WITH CHANGES See Section 13.0 .ITEM: LINE ASSEMU, FLEXIBLE AND FITTINGS. .FUNCTION: TO PROVIDE COUPLING SETWEEN PROPELLANT SUBSYSTEM AND FORWARD RCS PRIMARY AND VERNIER THRUSTER. .FAILURE MCDE: EXTERNAL LEAKAGE -(5)

.CAUSE(S):
. FATIGUE, SHOCK: VISRATION, HANDLING.

RUPTURE OF LINE OR COUPLING.

- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- . (A) LUSS OF PROPELLANTS TO EXTENT OF LEAK SIZE. (B) INCREASED GN&C CONTROL & USE OF ALTERNATE THRUSTERS. (C) POTENTIAL MISSION TERMINATION PRIOR TO PLANNED TIME. (D) NO EFFECT AFTER ASCENT UNLESS LEAK IS EXCESSIVE & RESULTS IN IGNITION WITH REACTANT (2NO ORDER FAILURE) DUPING A RTLS ABORT THE LOSS OF A MANIFOLD RESULTS IN THE LOSS OF TWO DOWN FIRING THRUSTERS WHICH RESULTS IN CRIT 1. DURING ASCENT THE FAILURE CANNOT BE DETECTED AND ISOLATED WHICH RESULTS IN POSSIBLE LOSS OF VEHICLE. ~
- .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
- (A) DESIGN BURST PRESSURE IS UP TO 3 TIMES THE MAX OPER PRESSURE OF 700 PSIS. PROOF PRESSURE IS UP TO 1.5 TIMES THE MAX OPER PRESSURE. THE DESIGN ALLOWS SUFFICIENT MOVEMENT TO PRECLUDE EXCESSIVE STRESSES DURING INSTALLATION AND OPERATION. LINES CAN BE ISOLATED AT THE MANIFOLD IN CASE OF LEAKAGE. (B) POST INSTALLATION TEST AND OPERATIONAL CHECKOUTS WILL VERIFY SYSTEM INTEGRITY. ALL LINES SUBJECTED TO PROOF PRESSURE DURING ATP AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS DURING QUAL TESTING. LINES ARE ALSO TESTED DURING SYSTEM EVALUATION AT WHITE SANDS TEST FACILITY. (C) SEE FMEA/CIL 102136-1. (D) NO HISTORY OF FAILURE IN FLIGHT. (NEW DEVELOPMENT ITEM FOR MANNED FLIGHT APPLICATION.

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HARDWARE/SOFTWARE ANALYSIS CHECKLIST 03-2F-121311-1 Fwd. Reaction Control SD75-SH-0016A FMEA NUMBER FAILURE MODE <u>Improper Mixture Ratio</u> ITEM _Injector Plate 1. DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY X RO YES ANNUNCIATE OR TAKE ACTION IN RESPONSE)? IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD la. USE TO DETECT THE FAILURE? 2. ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF X *NO YES IN-FLIGHT DETECTABILITY? 3. DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE IX I YES NO (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? 3a. IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTMARE TO COMPENSATE FOR THIS χ *YES NO FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)? AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR 4. X *YES 110 INDUCE ANOTHER FAILURE? 5. CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT \mathbf{x} NO OTHER FUNCTIONS? HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW 6. ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY. IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED N/A YES 110 X TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION? IF THE ANSWER TO EITHER 1 OR 3 IS YES: 8. CAN THE BFS BE ENGAGED AFTER OCCURRENCE? B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREM/VEHICLE? *EXPLANATION REQUIRED (SEE BELOW) CHANGE/RETERTION RATIONALE SUMPERS 1. \[KO H/S ISSUES 3. NO SOFTWARE DETECTION 5. ACCEPTANCE RATIONALE BELGM 6. RECOMMENDED CHANGES BELOW 2. X HARDWARE ACCEPTS RISK 4. DETECTION DURING CHECKOUT FMEA CHANGE RECOMMENDED EXPLANATION/COMMENTS: "Fail Off" in RCS RM if sufficiently blocked. 94

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - CRBITER 102

ET2Y3 cti 2	M :FWE - REACTION CO	NTROL F	MEA NO	03-2F	-12131	1-1	ΚE	:V÷£1	/14/	7
.ASSEMBLY	:THRUSTER, PRIMARY	A	SCRT: A	ABORT		CKI	T. Fu	INC:	12	
•P/N RI	:MC467-0028		RTLS			CRI	Γ. +	wJ:	5	
.P/N VEND	0R:X30868	M	ISSIONS	S: HF	VF X	rF	υF	51	4	
.QUANTITY	: 14	P	HASE(S)): PL	LG X	ئان .	OQ X	X LS	<u>`</u>	
•	: ONE INJECTOR PROV	IDED FO N	UMBER C	OF SUC	CESS PA	THS :	REMA I	NINC	,	
•	R EACH PRIMARY TH	•							2	
•		REDU	NDANCY	SCREEN	i: A-F	AIL	b-FA	IL	C-FA	ΙI
.FAILUKE	DETECTABLE IN FLIGHT	?. NO			TIME	10 E	FFECT	i :		
•					SECON	DS				
•					REFER	ENCE	Duct	MENT	rs:	
•					MJ070	-000	1-CIA	i.		
.GRTUND I	URNAKCUND?	NO			SD72-	SH-0	100-2			
•					vs 70-	4210	01			
••										
•										
•										
•	PREPARED BY:			API	PROVED	EY:				
•	DE 2	W SE	ARCY		DES					
•	REL	R D	IEHL		REL					
•										

.1TEM: INJECTOR, PLATE

.FUNCTION:

- TO RECEIVE FUEL AND OXIDIZER FROM THRUSTER INLET VALVES AND PROVIDE SOUBLET MIXING AT 1.60 OX TO FUEL (WEIGHT) RATIO FOR A HYPLRGULIC REACTION WHICH PRODUCES \$25 POUNDS OF THRUST AT 70,000 FEET. ALSO CONTROL CHAMBER WALL COOLING.
- •FAILURE MODE: FAILS TO DELIVER PROPS (F)
- AT PROPER MIXTURE RATIO AND FAILS TO PROVIDE ADEQUATE COOLING OF THE COMBUSTOR WALL.
- .CAUSE(S):
- . CONTAMINATION, BLOCKED GRIFICES.
- .EFFECT(S): GN (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VehICLE:
- . (A) LOSS OF ONE THRUSTER IN A GIVEN AXIS. (B) GN&C CONTROL SWITCHING
- . REQUIRED. (C,D) NO EFFECT. (E) POSSIBLE LOSS OF VEHICLE IF FAILURE OCCURS BEFORE ET SEPARATION. DOWN FIRING THRUSTERS REQUIRED FOR ET SEPARATION.
- .CORRECTING ACTION:
- SWITCH TO REDUNDANT THRUSTER IN AFFECTED AXIS. ISCLATE MARIFOLD CONTAINING FAILED THRUSTER.
- .REMARKS/HAZARDS:
- POSSIBLE LOCAL HOT SPOT RESULTING IN COATING DAMAGE OR COMBUSTUF BURN THROUGH.

ORIGINAL PAGE IS OF POOR QUALITY

REV:11/14/78 FMEA NO 03-2F -121311-1 SUBSYSTEM :FWD - REACTION CONTROL CRIT. FUNC: IR ABORT: ABORT .ASSEMBLY :THRUSTER, PRIMARY 3 CRIT. HDn: RTLS .P/N RI :40467-0028 HF VF X FF OF SH *** 2001221M** .P/N VENDOR:X30888 LC X OO X DO X LS .QUANTITY :14 PHASE(S): PL

ONE INJECTOR PROVIDED FOR EACH PRIMARY THRUSTER

REDUNDANCY SCREEN: A-FAIL B-FAIL C-FAIL

.PREPARED BY: .DES W SEA

W SEARCY R DIEHL DES inwitcher

REL C. E. January 15/7 F

SSM W. KOLLANUL

DÉLETE

See Section 13.0

.ITEM: INJECTOR: PLATE

.FUNCTION:

.REL

- . TO RECEIVE FUEL AND OXIDIZER FROM THRUSTER INLET VALVES AND PROVIDE DOUBLET MIXING AT 1.60 OX TO FUEL (WEIGHT) RATIO FOR A HYPERGOLIC REACTION WHICH PRODUCES 825 POUNDS OF THRUST AT 70,000 FFET. ALSO CONTROL CHAMBER WALL COOLING.
- .FAILURE MODE: FAILS TO DELIVER PROPS (F)
- . AT PROPER MIXTURE RATIO AND FAILS TO PROVIDE ADEQUATE COOLING OF THE COMBUSTOR WALL.

.CAUSE(S):

- . CONTAMINATION, BLOCKED ORIFICES.
- , EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/ VEHICLE:
- . (A) LOSS OF ONE THRUSTER IN A GIVEN AXIS. (B) GN&C CONTROL SWITCHING REQUIRED. (C.D) NO EFFECT. (E) POSSIBLE LCSS OF VEHICLE IF FAILURE OCCURS BEFORE ET SEPARATION. DOWN FIRING THRUSTERS REQUIRED FOR ET SEPARATION.
- .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
- (A) 75 MICRON FILTER PROVIDED UPSTREAM TO PRECLUDE CONTAMINATION
 FUEL HAS BEEN FILTERED TO 25 MICRONS PRIOR TO ENTERING TANK. ACOUSTIC
 CAVITIES PRECLUDE OCCURRENCE OF COMBUSTION INSTABILITY IN THE EVENT OF
 POOR DISTRIBUTION. (B) TOTAL FLOW & FLOW DISTRIBUTION CHECKED BY WATER
 FLOW TEST AND VERIFIED BY BURN TEST DURING THRUSTER ACCEPTANCE TESTS.
 (C) FIBER OPTICS USED TO VISUALLY INSPECT INJECTOR HOLES FOR EVIDENCE
 OF BURRS AND CONTAMINATION PRIOR TO ASSEMBLY AUDIT CONDUCTED ON 9-2-76
 VERIFIED THAT SUPPLIER INSPECTION CONTROLS RAW MATL VERIFICATION, PARTS
 PROTECTION, MFG FAB AND ASSY OPERATIONS, CONTAMINATION CONTRL, CORROSION
 CONTROL PROVISIONS AND STORAGE ENVIRONMENTS. TURN AROUND INSPECTION TO
 INCLUDE USE OF OPTICS INSPECTION WHERE ACCESSABLE FOR EVIDENCE OF DAMAGE
 & SYSTEM FLUID SAMPLINGS FOR DETECTION OF CONTAMINATION. (D) NO
 FAILURES OF THIS TYPE ON APOLLO.

	SUBSYSTEM Fwd. Reaction	Control	FMEA HUMBER	- + -· ·				
	ITEM Thrust Chamber		FAILURE MODE Bur	rn Through				
1.	DOES THE FLIGHT SOFTWARE DETECT	T THIS FAILURE MODE (i.	e., AUTOMATICALLY	YES	Д ио П			
la.	ANNUNCIATE OR TAKE ACTION IN RE IF NOT, DOES THE HARDWARE PROVI USE TO DETECT THE FAILURE?	•	E FLIGHT SOFTWARE	COULD *YES	□ NO □			
2.	ARE THE ANSWERS TO QUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND la CONSISTENT WITH	THE FMEA EVALUATI	ON OF YES	X *NO			
3.	DOES THE FLIGHT SOFTWARE TAKE / (EITHER BY COMMANDING HARDWARE	ACTION TO NEGATE THE EF ACTION OR IMPLEMENTING	FECTS OF THE FAILU	IRE YES 1 LOGIC)?	□ ио 🗴			
3a.	IF NOT, DOES THE CAPABILITY EXT FAILURE MODE (EITHER BY COMMAND PROGRAM LOGIC)?				NO X			
4.	AS A RESULT OF THIS FAILURE MODE INDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE OV	ERSTRESS THE HARDW	IARE OR *YES	□ № 🗓			
5.	CAN THIS FAILURE MODE, IN COMBIOTHER FUNCTIONS?	INATION WITH SOFTWARE L	OGIC, ADVERSELY AF	FFECT *YES	□ ио 🗵			
6.	HOW MANY OF THESE HARDWARE FAIL ACTION AND HARDWARE/SOFTWARE OF	LURES CAN THE SHUTTLE T PERATION)? NOTE CHANGE	OLERATE (CONSIDER TO FMEA CRITICALI	CREW *0 [] *1			
7.	IF CREW ACTION IS REQUIRED TO F TO SIGNAL THE NEED FOR INTERVEN	RESPOND TO THIS FAILURE WTION AND THE REQUIRED	MODE, ARE CUES PR CORRECTIVE ACTION?	ROVIDED II/A	YES X 110			
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:			- 			
	A. CAN THE BFS BE ENGAGED AFTE							
*CAD1	B. WILL BFS TOLERATE FAILURE WARMATION REQUIRED (SEE PELOW)	WITHOUT LOSS OF CREW/VE	HICLE?	YES				
	JANTION REQUIRED (SEE POLOS)							
CHANG	SE/RETENTION RATIONALE SUPTARY							
] NO H/S ISSUES	3. \(\square\) NO SOFTWARE DET			•			
2.	J HARDWARE ACCEPTS RISK	4. DETECTION DURIN	G CHECKOUT 6.	RECOMMENDED	CHANGES BELOW			
				•				
			X FMEA CHANGE R	FCOMMENDED				
	Elither Charact Accordances							
EXF	EXPLANATION/COMMENTS:							
FMEA change - Measurement numbers V42X1541X through V42X1556X should be listed as V42P1541A through V42P1556A.								
l. giv	RM uses thurst chamber prove a "fail off" in RCS RM.	essure transducers t	co sense the low	pressure in o	question and			
· 7.	The thrust chamber measure	ements are downlinke	d .					
	*		•					

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM	:FNU - REACTIO	N CONTROL	FMEA NO	03-2F	-121312-1	REV:	11/10/7
·ASSEMELY	:THRUSTER, PRI	MARY	ASURT:		CK	IT. FUNC	ì
.P/N RI	:MC467-0028				CR	IT. HWD	: i
.P/N VENDOR	X × X 3 C 9 58		MISSIONS	S: HF	VF X FF	OF.	SM
.QUANTITY	:14		PHASE(S)): PL	LC X 00	X DO X	LS
•	:ONE PER THRUS	TER	NUMB ER C	OF SUCC	ESS PATHS	KEMAIN1	NG
•	•		AFTER F	IRST FA	ILURE:		2
•		R E E	DUNDANCY	SCREEN	: A-N/A	e-N/A	C-N/A
.FAILURE DE	ETECTABLE IN FL	IGHT? YES			TIME TO	EFFECT:	
.INC1P1ENT	BURN-THRU DETE	CTORS V42X19	541X THRO	JUGH	SECONDS		
.V42X1556X	PC TRANS	DUCER IF LEA	AKAGE		REFERENC	E SUCUME	NTS:
.IS GROSS	(1b)				MJ070-00	01-318	
.GROUND TUR	RNAROUND?	YES			SD72-SH-	0103-2	
.VISUAL EXA	MINATION				VS70-421	C01	
•							
•							
•							
•	PREPARED 6	3Y:		APP	ROVED BY:		
•	DES	₩ :	SEARCY		DES		
•	REL	R	DIEHL		REL		
_							

.ITEM: THRUST CHAMBER

- FROM INJECTOR TO NOZZLE EXTENSION (COATED COLUMBIUM).
- .FUNCTION:
- TO CONTAIN HYPERGOLIC REACTION OF PROPELLANTS AND TO EXPAND COMBUSTION PRODUCTS TO PRODUCE THRUST THROUGH NOZZIE EXTENSION TO PROVIDE IMPULSE TO VEHICLE.
- .FAILURE MODE: OVERHEAT/BURNTHROUGH (5)
- DUE TO INADEQUATE COOLING.
- .CAUSE(S):
- BLOCKED (CONTAMINATED) COOLANT (FUEL) INJECTOR HOLES, POOR EOUNDARY FLOW CONDITIONS COMBUSTION INSTABILITY, SEPARATION OR FRACTURE UF PROTECTIVE DISLICIDE COATING.
- .EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES, (C) MISSION (D) CREW/VEHICLE:
- . (A) LOSS OF A PRIMARY THRUSTER IN A GÍVEN AXIS. (B) INCREASED GNOC
- CONTROL AUTHORITY REQUIRED. (C) POTENTIAL LOSS OF MISSION ADORT DECISION. (D) POTENTIAL LOSS OF VEHICLE. CRITICAL DAMAGE COULD OCCUR BEFORE FAILURE IS DETECTED.
- .CORRECTING ACTION:
- ISOLATE THRUSTER AND UTILIZE REDUNDANT THRUSTER IN AFFECTED AXIS. (AUTOMATIC FUNCTION).
- .REMARKS/HAZARDS:
- POTENTIAL HAZARD FROM ESCAPING HOT GASES IN MODULE AND PUTENTIAL PROPAGATION OF FAILURE IF NOT ISOLATED IN A TIMELY MANNER.

SUBSYSTEM :FWD - REACTION CONTROL FME4 NO 03-2F -121312-1 REV:11/10/78 CRIT. FUNC: .ASSEMBLY :THRUSTER, PRIMARY ABORT: 1 :4C467-0029 CRIT. HDW: -P/N RI HF VF X FF OF -P/N VENDOR: X30958 #ISSIONS: SM PHASE(S): PL LO X OO X DO X LS -DUANTITY :14

ONE PER THRUSTER

•

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

See Section 13.0

APPROVED BY:

APPROVED WITH CHANGES

.ITEM: THRUST CHAMBER

FROM INJECTOR TO NOZZLE EXTENSION (COATED COLUMBIUM).

FUNCTION:

• TO CONTAIN HYPERGOLIC REACTION OF PROPELLANTS AND TO EXPAND COMBUSTION PRODUCTS TO PRODUCE THRUST THROUGH NOZZLE EXTENSION TO PROVIDE IMPULSE TO VEHICLE.

FAILURE MODE: OVERHEAT/BURNTHROUGH (S)

. DUE TO INADEQUATE COOLING.

.CAUSE(S):

- BLOCKED (CONTAMINATED) COOLANT (FUEL) INJECTOR HOLES, POOR BOUNDARY FLOW CONDITIONS COMBUSTION INSTABILITY, SEPARATION OR FRACTURE OF PROTECTIVE DISLICIDE COATING.
- EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREM/VEHICLE:
 (A) LOSS OF A PRIMARY THRUSTER IN A GIVEN AXIS. (B) INCPEASED GN&C
 CONTROL AUTHORITY REQUIRED. (C) POTENTIAL LOSS OF MISSION ABORT
 DECISION. (D) POTENTIAL LOSS OF VEHICLE. CRITICAL DAMAGE COULD OCCUR
 BEFORE FAILURE IS DETECTED.
- DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
 INTERMETALIC DIFFUSSION LAYER FORMS AN INTEGRAL BOND BETWEEN THE
 DISTLICIDE COATING AND THE PARENT COLUMBIUM MATERIAL AND TENDS TO RESIST

SHOCK LOADING. 75 MICRON FILTER IN VALVE INLET UPSTREAM OF INJECTOR HOLES WILL PRECLUDE ENTRY OF CONTAMINANTS. ACOSTIC CAVITIES DAMPEN THE FREQUENCIES THAT EXCITE INSTABILITY. (B) SIMULATED THRUSTERS AND THRUSTER NO. 5 VIBRATION TESTS HAVE DEMONSTRATED THE ABILITY OF THE DISILICIDE COATING TO WITHSTAND 2.0 G SQUARED PER HERTZ RANDOM VIBRATION STRESSES. THRUSTER IS SUBJECTED TO RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS DURING THE QUAL. PROGRAM. (C) COATING THICKNESS AND QUALITY WILL BE CONTROLLED BY SUPPLIER INSPECTION PROCEDURE MPS 525 WHICH REQUIRES CERTIFICATION THAT COATING PROCESS CONFORMS TO THE PROCESS SPEC. VISUAL INSPECTION, VERIFICATION OF COATING THICKNESS AND A SMOKE TEST THAT VERIFIES COAT INTEGRITY. TURNAROUND INSPECTION TO INCLUDE VISUAL INSPECTION FOR EVIDENCE OF BURN THRU. FAILURE HISTORY. (2) DEVELOPMENT FAILURES HAVE OCCURRED ON SHUTTLE PROGRAM. ONE FAILURE DUE TO DOUBLET DESIGN WHICH HAS BEEN CHANGED AND DEE FAILURE DUE TO THIN COAT OF DISILICIDE COATING. THIN COAT STILL WITHSTOOD MORE FIRING TIME THAN IS NORMALLY SEEN BY THE THRUSTER IN NORMAL 100 MISSION LIFE.

	SUBSYS	TEM Fwd Reaction	· nakuwake750FT Control	VARE ANALYSIS CHI FMEA NUMBER			
		Nozzle Extension		FAILURE MODE			
					DUIT-III U		····
1.	DOES TH	E FLIGHT SOFTWARE DE ATE OR TAKE ACTION I	TECT THIS FAILURE MOUNTED THE TECHNOLOGY.	DE (i.e., AUTOMATICA	ALLY .	YES NO	X
la.	IF NOT, USE TO	DOES THE HARDWARE P DETECT THE FAILURE?	ROVIDE INFORMATION TH	AT THE FLIGHT SOFTW	ARE COULD	*YES NO	
2.	ARE THE IN-FLIG	ANSWERS TO QUESTION HT DETECTABILITY?	S 1 AND 1a CONSISTENT	WITH THE FMEA EVAL	LUATION OF	YES X *NO	
3.	DOES TH (EITHER	E FLIGHT SOFTWARE TA BY COMMANDING HARDW	KE ACTION TO NEGATE T PARE ACTION OR IMPLEME	THE EFFECTS OF THE E	FAILURE OGRAM LOGIC)?	YES NO	X
3a.	FAILURE	DOES THE CAPABILITY MODE. (EITHER BY COMLOGIC)?	EXIST FOR THE SOFTWA MANDING HAROWARE ACTI	RE TO COMPENSATE FO ON OR IMPLEMENTING	OR THIS ALTERNATE	*YES X NO	
4.	AS A REI	SULT OF THIS FAILURE ANOTHER FAILURE?	MODE, CAN THE SOFTWA	RE OVERSTRESS THE F	HARDWARE OR	*YES 110	Image: section of the
5.	CAN THIS	S FAILURE MODE, IN C UNCTIONS?	OMBINATION WITH SOFTW	MARE LOGIC, ADVERSEL	LY AFFECT	*YES \[\] NO	X
6.	HOW MAN'	Y OF THESE HARDWARE AND HARDWARE/SOFTWAR	FAILURES CAN THE SHUT E OPERATION)? NOTE C	TLE TOLERATE (CONSI HANGE TO FMEA CRITI	IDER CREW ICALITY.	*0 *1 :	2 X
7.	IF CREW TO SIGN	ACTION IS REQUIRED AL THE NEED FOR INTE	TO RESPOND TO THIS FA RVENTION AND THE REQU	ILURE MODE, ARE CUE IRED CORRECTIVE ACT	ES PROVIDED FICH?	N/A YESX iii	0 🗌
8.	IF THE	ANSWER TO EITHER 1 O	R 3 IS YES: .		_	-	
	A. CAN	THE BFS BE ENGAGED	AFTER OCCURRENCE?			YES X *NO	
	B. WILI	L BFS TOLERATE FAILU	RE WITHOUT LOSS OF CR	EW/VEHICLE? .		YES X *NO	
*EXP	LANATION	REQUIRED (SEE BELOW)				
	ce/percus	TION RATIONALE SUMMA					-
			3. NO SOFTWAR	PE DETECTION	r Maccon	TANCE DATIONALE	הרו היי
		• •	4. DETECTION			MENDED CHANGES	
-			•	•	••		•
		•		FMEA CHAN	IGE RECOMMENDE	٥	
- ,							
EXI	PLANATION	1/COMMENTS:	. ,		•		
	•						
3a.	Instr	umentation is ava	ilable for software	e redesign.			

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - URBITER 102

	ABURT: ABU RTLS MISSIONS: PHASE(S): NUMBER OF AFTER FIRS REDUNDANCY SC	RT, CRIT. F	UNC: I HWG: I SM X LS INING 2 I/A C-N/A .T: CUMENTS:
	W SEARCY R DIEHL	APPROVED BY: DES	
ITEM: NOZZLE EXTENSION, COATED COLUMBIUM (WITH INSULATION) FUNCTION: TO PROVIDE FOR EXPANSION OF COME REQUIRED THRUST IS PRODUCED. FAILURE MODE: STRUCTURAL FAILURE BURN-THRU. CAUSE(S): HIGH TEMPERATURE IN LOCAL SPOT (INJECTOR COOLANT HOLES) VIBRATION EFFECT(S): ON (A) SUBS YSTEM (B) INTO (A) LOSS OF A THRUSTER IN A GIVE AUTHORITY REQUIRED. (C) NO EFF	BUSTION GASES (S) DUE TO FILM COON, SHOCK, WEE ERFACES (C)MIE EN AXIS. (B FECT. (D) NO	BOLING FAILURE(CONT LO OR MATERIAL DEFE SSION (D)CREW/VEHIO) INCREASED GN&C CO EFFECT UNLESS FAIR	FAMINATED EUT. ELE: UNTRUL EURE

ORIGINAL PAGE IS OF POOR QUALITY

ISOLATE THRUSTER AT INLET VALVE OR MANIFOLD AND UTILIZE ALTERNATE IN

POTENTIAL FOR FAILURE PROPOGATION TO ADJACENT THRUSTERS IF INSULATION

BLANKET DOES NOT PRECLUDE GAS/LIQUID ESCAPING. REFERENCE HAZAKU

LEVEL

.CORRECTING ACTION:

1YXX-0302-01.

AFFECTED AXIS.. REMARKS/HAZARDS:

FMEA NO 03-2F -121313-1 SUBSYSTEM : FWD - REACTION CONTPOL REV: 11/14/ ABORT: ABORT, CRIT. FUNC: .ASSEMBLY : THRUSTER, PRIMARY .P/N RI RTLS CRIT. HDh: 1 :MC467-0028 MISSIONS: VF X FF OΕ •P/N VENDOR: X30872 HF SM LO X GO X DO X LS PHASE(S): PL **QUANTITY** 1.4 :ONE PER THRUSTER REDUNDANCY SCREEN: A-N/A 8-N/A APPROVED 94 (NASA): .PREPARED BY: APPROVED BY: Page De SSM .DES N SEARCY DES C. E. Darse 13/15778 BEL -REL R DIEHL REL ቸጽбVED WITH CHANGES .ITEM: NOZZLE EXTENSION. See Section 13.0

. COATED COLUMBIUM (WITH INSULATION BLANKET).

.FUNCTION:

■ TO PROVIDE FOR EXPANSION OF COMBUSTION GASES TO H>1 SUCH THAT THE REQUIRED THRUST IS PRODUCED.

.FAILURE MODE: STRUCTURAL FAILURE, (S)

BURN-THRU.

.CAUSE(S):

- HIGH TEMPERATURE IN LOCAL SPOT DUE TO FILM COOLING FAILUPE(CONTAMINATED INJECTOR COOLANT HOLES) VIBRATION, SHOCK, WELD OR MATERIAL DEFECT.
- .EFFECT(S): ON (A) SUBSYSTEY (B) INTERFACES (C) MISSION (D) CREW/VEHICLE:
- (A) LOSS OF A THRUSTER IN A GIVEN AXIS. (B) INCREASED GHEC CONTROL
 AUTHORITY REQUIRED. (C) NO EFFECT. (D) NO EFFECT UNLESS FAILURE
 PROPAGATES-CRITI FOR RTLS ABORT IF THRUSTER IS ISOLATED AT MANIFOLD
 LEVEL

.DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY. (A) INTERMETALLIC DIFFUSION LAYER FORMS INTEGRAL SOND TO RESIST SHOCK. COATING PROCESS CONTROLLED. INJECTOR DESIGN INCORPORATES ACOUSTIC CAVITIES WHICH REDUCED POSSIBILITY OF INSTABILITY. CUCTILE PROPERTIES OF C-103 COLUMBIUM PRECLUDES FRAGMENTATION OR CATASTROPHIC MODE OF FAILURE. (B) DEV VIBRATION TESTS DEMONSTRATE ABILITY OF DISILICIDE COATING TO WITHSTAND 2.0 G SQUARED/HZ RANDOM VIBRATION. TEMP TESTS DEMONSTRATE EXCELLENT DUCTIBLE/BRITTLE QUALIFIES FOR COATED C-103 COLUMBIUM. (C) TURNAROUND INSPECTION TO INCLUDE VISUAL INSPECTION FOR EVIDENCE OF BURN THROUGH & WHERE ACCESSABLE, USE OF FIBER-OPTICS NOE TO INSPECT FOR SURFACE FLAWS. SUPPLIER INSPECTION INCLUDES FLOUPESCENT PENETRATE INSPECTION PRIOR TO COATING TO DETECT SURFACE DEFECTS AND X-RAY INSPECTION IS REQUIRED FOR DETECTION OF INTERNAL DEFECTS. AUDIT CONDUCTED 9-2-76 VERIFIED THAT SUPPLIER INSPECTION CONTROLS ON MATIL, IDENTIFICATION OF PARTS, MFG PROCESSES, CORROSION PROTECTION. CONTAMINATION CONTROL AND ENVIRONMENTS. (D) 4 OCCURANCES OF BELL FAILURES CAUSED BY BRITTLE HETROGENEOUS GRAIN STRUCTURE OUE TO VISRATION FATIGUE ON APOLLO LM/SM RCS ENGINES.

	SUBSYSTEM Fwd. Reaction Co	ontrol	FMEA NUMBER		'5-SH-0016A			
	ITEM Vernier Thruster		FAILURE MODE	Loss of Ou	ıtput			
 -								
1.	DOES THE FLIGHT SOFTWARE DETECT ANNUNCIATE OR TAKE ACTION IN RE		.e., AUTOMATICALI	. Y	YES X NO			
la.	IF NOT, DOES THE HARDWARE PROVI USE TO DETECT THE FAILURE?	DE INFORMATION THAT TO	HE FLIGHT SOFTWAR	E COULD	*YES NO			
2.	ARE THE ANSWERS TO QUESTIONS 1 IN-FLIGHT DETECTABILITY?	AND Ta CONSISTEAT WIT	H THE FMEA EVALUA	ATION OF	YES X *NO			
3.	DOES THE FLIGHT SOFTWARE TAKE A (EITHER BY COMMANDING HARDWARE	ACTION TO NEGATE THE E ACTION OR IMPLEMENTIN	FFECTS OF THE FAI	ILURE VAM LOGIC)?	YES X 160			
3a.	IF NOT, DOES THE CAPABILITY EXT FAILURE MODE (EITHER BY COMMAND PROGRAM LOGIC)?	IST FOR THE SOFTWARE T DING HARDWARE ACTION O	O COMPENSATE FOR R IMPLEMENTING AL	THIS TERNATE	*YES NO			
4.	AS A RESULT OF THIS FAILURE MODINDUCE ANOTHER FAILURE?	DE, CAN THE SOFTWARE O	VERSTRESS THE HAR	RDWARE OR	*YES 110 X			
5.	CAN THIS FAILURE MODE, IN COMBIOTHER FUNCTIONS?	INATION WITH SOFTWARE	LOGIC, ADVERSELY	AFFECT	*YES NO X			
6.	HOW MANY OF THESE HARDWARE FAIL ACTION AND HARDWARE/SOFTWARE OF	LURES CAN THE SHUTTLE PERATION)? NOTE CHANG	TOLERATE (CONSIDE E TO FMEA CRITICA	ER CREW	*0 *1 2			
7.	IF CREW ACTION IS REQUIRED TO F TO SIGNAL THE NEED FOR INTERVEN	RESPOND TO THIS FAILUR ITION AND THE REQUIRED	E MODE, ARE CUES CORRECTIVE ACTIO	PROVIDED	N/A YESX::0			
8.	IF THE ANSWER TO EITHER 1 OR 3	IS YES:						
	A. CAN THE BFS BE ENGAGED AFTE	ER OCCURRENCE?			YES X *1:0			
	B. WILL BFS TOLERATE FAILURE !	/ITHOUT LOSS OF CREW/V	EHICLE?		YES X *KO			
*EX5	ANATION REQUIRED (SEE DELOW)							
	GE/RETENTION RATIONALE SUMMARY	• C No corruspe pe	~~~~					
	NO H/S ISSUES				TANCE RATIONALE BELOW			
2. (_)	MARDWARE ACCEPTS RISK	4. DETECTION DURI	NG CHECKOUT	6. LI RECOM	MENDED CHAMGES BELOW			
			•					
			*					
			•					
		•	FMEA CHANGE	RECOMMENDE	ס			
EXPLANATION/COMMENTS:								
	7							
giy	RM uses thrust chamber pre e_a_"fail_off"_in_RCS_RM	essure transducers	to sense the lo	ow pressur	e in question and			
3. (pr	The GN&C RM program will a covided it is not inhibited)	automatically desel). See FSSR "10" p	ect a failed je aragraph 4.1.7	et under c .1.6.3 for	ertain conditions the conditions.			
6.	This failure can be tolera	ted since it is cr	iticality 2.					
7.	7. The thrust chamber pressures can be downlinked;							

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -131310-1 REV:11/14/7 CRIT. FUNC: 2 7" .ASSEMBLY : THRUSTER ASSY ABORT: .P/N RI CRIT. HWD: :MC467-0029 2 .P/N VENDOR: MISSIONS: HF VF X FF CF PHASE(S): PL LO 36 X 00 LS .QUANTITY :2 :ONE REQ!D PER SIDE NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE: C : (DOWN FIRING) REDUNDANCY SCREEN: A-N/A E-N/A C-N/A TIME TO EFFECT: .FAILURE DETECTABLE IN FLIGHT?. YES IMMEDIATE .THRUSTER CHAMBER PRESS V42P-1555A, 1556A REFERENCE DOCUMENTS: MJG70-0001-018 SD72-SH-0103-2 .GROUND TURNAPOUND?.....YES VS70-421001 .POSITION INDICATION PREPARED EY: APPROVED SY: J TAGGART DES DES RE L R DIEHL REL .ITEM: THRUSTER. VERNIER (EN 157/158). .FUNCTION: TO PROVIDE THRUST FOR LOW LEVEL ACCELERATIONS ASSOCIATED WITH FCINTING MANEUVERS AND THREE AXIS ATTITUDE HOLD. THRUSTER FIRES IN +2 LIRECTION FOR + PITCH AND -Z ACCELERATION. INCLUDES INLET VALVE, INJECTUR, THRUST CHAMBER, NCZZLE EXTENSION, HEATER, INSULATION, PRESS/TEMP XSDUCERS. .FAILURE MODE: LOSS OF OUTPUT INLET VALVES/BLOCKED INJECTOR/STAND-OFF'S. .CAUSE(S): CONTAMINATION, PIECE PART STRUCTURAL FAILURE, IMPROPER SULENCIO ACTUATION, VIBRATION .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE: (A) LOSS OF VERNIER FUNCTION. (B) NO EFFECT. (C) POTENTIAL EARLY MISSION TERMINATION. LOSS OF TIGHT DEADGAND ATTITUDE CONTROL. (D) NO EFFECT. .CGRRECTING ACTION: UTILIZE LARGE THRUSTERS FOR ATTITUDE CONTROL IN AFFECTED AXIS (INCREASED PROPELLANT QUANTITY DEPLETION) •R EMARKS/HAZARDS: POTENTIAL HAZARD IF FAILURE OCCURS DURING CRITICAL MANEUVERS - TIME

CRITICAL. NO REDUNDANCY IS PROVIDED FOR THIS COMPONENT.

SHUTTLE CRITICAL ITEMS LIST - OPBITER 102

SUBSYSTEM : FWD - REACTION CONTROL FMEA NO 03-2F -131310-1 REV: 11/14/78 -ASSEMBLY : THRUSTER ASSY ABORT: CPIT. FUNC: 2 -P/N RI :MC467-0029 CRIT. : WGH -P/N VENDOR: VF X FF MISSIONS: H۶ ΩF SM -QUANTITY :2 PHASE(S): PL LO CO X DO LS :ONE REQ'D PER SIDE : (DOWN FIRING) REDUNDANCY SCREEN: $\Delta - N / \Delta$ B-N/A APPROVED BY INASA) .PREPARED BY: APPROVED BY: -DES Much J TAGGART SSM DES -REL R DIEHL REL

.ITEM: THRUSTER, VERNIER

(EN 157/158).

FUNCTION:

- TO PROVIDE THRUST FOR LOW LEVEL ACCELERATIONS ASSOCIATED WITH POINTING MANEUVERS AND THREE AXIS ATTITUDE HOLD. THRUSTEP FIRES IN +Z DIRECTION FOR + PITCH AND -Z ACCELERATION. INCLUDES INLET VALVE, INJECTOR, THRUST CHAMBER, NOZZLE EXTENSION, HEATER, INSULATION, PRESS/TEMP XSDUCERS.
- .FAILURE MODE: LOSS OF OUTPUT (F)
- . INLET VALVES/BLOCKED INJECTOR/STAND-OFF'S.
- .CAUSE(S):
- CONTAMINATION, PIECE PART STRUCTURAL FAILURE, IMPROPER SCLENCID ACTUATION, VIBRATION
- *EFFECT(S): ON (A)SUBSYSTEH (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF VERNIER FUNCTION. (B) NO EFFECT. (C) POTENTIAL EARLY MISSION TERMINATION. LOSS OF TIGHT DEADBAND ATTITUDE CONTROL. (D) NO EFFECT.
- -DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
- (A) VALVE INCORPORATES A 25 MICRON FILTER TO PRECLUDE CONTAMINATION.

 VALVE HAS BEEN DESIGNED TO PRECLUDE SELF GENERATED CONTAMINATES.

 SPECIAL EMPHASIS PLACED ON SOLENOID AND WIRING TO PRECLUDE SHORTS. (B)

 PRE/POST FLIGHT CHECKOUT AND VALVE SIGNATURE TESTS WHEN MODULE REMOVED.

 VALVE SUBJECTED TO RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS DURING OUAL PROGRAM. LENGTH OF TIME FOR VIBRATION TO EQUAL 100 MISSION LIFE EXPECTANCY. (C) AUDIT CONDUCTED 9-2-76 VERIFIED THAT SUPPLIER INSPECTION CONTROLS RAW MATIL. IDENTIFICATION OF PARTS, MFG PROCESSES, CORROSION PROTECTION. CONTAMINATION CONTROL, AND ELECTRICAL TERMINATIONS. TURNAROUND INSPECTION INCLUDES MONITORING FUNCTIONAL TEST DURING PRESSURIZATION CYCLE FOR EVIDENCE OF ERRATIC OPERATION. (D) NO FAILURE HISTORY APPLICABLE TO THIS FAILURE MODE.

	SUBSYSTEM _	<u>Fwd Rea</u>		itrol	FMEA NU	MBER	_	03-2F- SD75-S		
						MODE	Erratic			
1.	DOES THE FLIC	SHT SOFTWAR TAKE ACT	ARE DETECT FION IN RES	THIS FAILURE	MODE (i.e., AUT	OHATICAL	LY	YES	□ N	0 X
là.	IF NOT, DOES USE TO DETECT	THE HARDW	ARE PROVID	E INFORMATION	THAT THE FLIGHT	T SOFTWAR	RE COULD	*YES	☐ N	0 🔲
2.	ARE THE ANSWE			ND la CONSIST	ENT WITH THE FM	IEA EVALU	ATION OF	YES	X *N	0 🔲
3.					E THE EFFECTS O			YES	X NO	0 🔲
3a.		(EITHER I			TWARE TO COMPEN CTION OR IMPLEN			*YES	□ NO	·
4.	AS A RESULT O	F THIS FA	AILURE MODE ?	, CAN THE SOFT	TWARE OVERSTRES	S THE HA	RDWARE OR	*YES	☐ NO	0 X
5.	CAN THIS FAIL OTHER FUNCTION	URE MODE.	, IN COMBIN	ATION WITH SO	FTWARE LOGIC, A	DVERSELY	AFFECT	*YES	□ NO	OX
6.	HOW MANY OF TACTION AND HA	HESE HARO	WARE FAILU FTWARE OPE	RES CAN THE SI RATION)? NOTE	HUTTLE TOLERATE E CHANGE TO FME	(CONSID	ER CREW ALITY.	*0 [*1X	2
7.	IF CREW ACTION TO SIGNAL THE	NI IS REQU NEED FOR	IRED TO RE	SPOND TO THIS	FAILURE MODE, EQUIRED CORRECT	ARE CUES	PROVIDED	N/A []YES[X	110
8.	IF THE ANSHER	TO EITHE	R 1 OR 3 I	S YES:	•			•		
	A. CAN THE E	SFS BE ENG	AGED AFTER	OCCURRENCE?				YES	X *#0	о П
	B. WILL BFS	TOLERATE	FAILURE WI	THOUT LOSS OF	CREW/VEHICLE?			YES		
*EXP	LANATION REQUI				•					
CHANG	GE/RETENTION R	CATIONALE	SUMMARY		•			-		•
1.] NO H/S ISSUE	:s		3. NO SOFTI	WARE DETECTION		5. ACCE	PTANCE R	IAMOI TA	LE BELOW
2. X] HARDWARE ACC	EPTS RIS	〈	4. DETECTION	ON DURING CHECK	OUT	6. 🗖 RECO	MENDED	CHANGE:	S BELOW
					•					
						. 1	•			
		•	-	-	No In- I⊽leve	Flight	Detectabi E RECOMMEND	lity		A*
					VILVE	A CHANG	c KECUMMEND	:		
EXI	PLANATION/COMM	ENTS:					- -			_
					•	_				-

1. May not be detected unless 3 consecutive low pressures.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - DRBITER 102

· A SSEMBLY	:FWL - REACTION CONTROL : FHRUSTER ASSY :MC467-0029		-13131C-3 REV:11/10/7 CRIT. FUNC: 2 CRIT. FWD: 2
•P/N VENDOR		MTCCIONC. UE	VF X FF OF SM
•QUANTITY		PHASE(S): PL	
	ONE REQ'D PER SIDE	NUMBER OF SHCC	ESS PATHS REMAINING
	:(DOWN FIRING)	AFTER FIRST FA	ILURE:
-			: A-V/A 6-V/A C-N/A
.FAILURE DE	ETECTABLE IN FLIGHT? . YES		TIME TO EFFECT:
.THRUSTER (CHAMBER PRESS. INDICATION	V42P-1555A	IMMEDIATE
.1556A			REFERENCE DOCUMENTS:
•			MJ070-0001-01E
.GROUND TUR	RNAKOUND?NO		S072-5H-0103-2
•			VS70-421C01
•			_
•			
•	PREPARED BY:	ΔΡΡ	RGVED 6Y:
•		AGGART	
•		DIEHL	
•			
•			
	USTER, VERNIER		
• (EN 157)	/158).		
.FUNCTION:	the TubuleT eas couldens. In		COTATE BUILD BOTHTING
	IDE THRUST FOR LOW LEVEL AC RS AND THREE AXIS ATTITUDE		
	ITCH AND -Z ACCELERATION.		
	CHAMBER, NOZZLE EXTENSION,		
X SOUCER:		HERIENY INCOLAI	10114 1 11000 1 1111
	ODE: ERRATIC OPERATION	(F)	
	H THRUST OR INTERMITTENT OF		
.CAUSE(S):			
	NATION, IMPROPER SOLENOID A		
	: ON (A) SUBSYSTEM (B) INTERF		
• (A) LOS	S OF VERNIER CONTROL E) I	INTERFACE SWITCH	ING OF PUWER AND
	NTROL TO LARGE THRUSTERS.		
	NIER THRUSTERS WOULD HAVE T E CONTROL WOULD BE LOST. (GCA FART IIGHT DEADDAND
• CERRECTIN		ID) MOME	
	WN/ISOLATE FAILED THRUSTER	AND UTTLIZE LAR	GE THRUSTER IN
AFFECTE		DIRELEE EAR	
-REMARKS/H			
	AL HAZARD FROM COLLISION. N	O REDUNDANCY IS	PROVIDED FOR THIS
COMPONE			

SHUTTLE CRITICAL ITEMS LIST - CRBITER 102

SUBSYSTEM :FWD - REACTION CONTPOL FMEA NO 03-2F -131310-3 CIVII:V3S CRIT. FUNC: .ASSEMBLY : THRUSTER ASSY ABORT: .P/N RI :40467-0029 CR IT. HOW: 2 -P/N VENDOR: VE X FF OF MISSIONS: HF SΥ LO 00 X 00 -OUANTITY :2 PHASE(S): PL LS :ONE REQ'D PER SIDE

. :(DOWN FIRING)

REDUNDANCY SCREEN: A-N/A

REDUNDANCY SCREEN: A-N/A B-N/A C-N/

.ITEM: THRUSTER, VERNIER

. (EN 157/158).

.FUNCTION:

- TO PROVIDE THRUST FOR LOW LEVEL ACCELERATIONS ASSOCIATED % ITH PCINTING MANEUVERS AND THREE AXIS ATTITUDE HOLD. THRUSTER FIRES IN +Z DIRECTION FOR ← PITCH AND ~Z ACCELERATION. INCLUDES INLET VALVE, INJECTOR, THRUST CHAMBER, NOZZLE EXTENSION, HEATER, INSULATION, PRESS/TEMP XSDUCERS.
- .FAILURE MODE: ERRATIC OPEPATION (F)
- . LOW/HIGH THRUST OR INTERMITTENT OPERATION

.CAUSE(S):

- CONTAKINATION, IMPROPER SOLENGID ACTUATION.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF VERNIER CONTROL B) INTERFACE SWITCHING OF POWER AND GNEC CONTROL TO LARGE THRUSTERS. (C) POSSIBLE EARLY MISSION TERMINATION BOTH VENIER THRUSTERS WOULD HAVE TO BE ISOLATED SUCH THAT TIGHT DEADBAND ATTITUDE CONTROL WOULD BE LOST. (D) NONE.
- .DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
- (A) VALVE INCORPORATES A 75 MICRON FILTER TO PRECLUDE CONTAMINATION.

 VALVE HAS BEEN DESIGNED TO PRECLUDE SELF GENERATED CONTAMINATES.

 SPECIAL EMPHASIS PLACED ON SCLENDID AND WIRING TO PRECLUDE SHORTS. (B)

 PRE/POST FLIGHT CHECKOUT AND VALVE SIGNATURES TESTS WHEN MCDULE REMOVED.

 VALVE SUBJECTED TO RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS OURING

 QUAL PROGRAM. LENGTH OF TIME FOR VIBRATION TO EQUAL 100 MISSION LIFE

 EXPECTANCY. (C) AUDIT CONDUCTED 9-2-75 VERIFIED THAT SUPPLIER

 INSPECTION CONTROLS RAW MATIL. IDENTIFICATION OF PARTS. MFG PROCESSES.

 CORROSION PROTECTION. CONTAMINATION CONTROL. AND ELECTRICAL

 TERMINATIONS. TURNAROUND INSPECTION INCLUDES MONITORING FUNCTIONAL TEST

 DURING PRESSURIZATION CYCLE FOR EVIDENCE OF ERRATIC OPERATION. (D) MO

 FAILURE HISTORY CONCERNING THIS FAILURE MODE.

	HARDWARE/SOFTWARE SUBSYSTEM Fwd. Reaction Control		CKLIST 03-2F-131310-4 SD75-SH-0016A					
	ITEM Vernier Thruster	FAILURE MODE						
1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e. AUTOMATICAL	LY YES X NO					
•	ANNUNCIATE OR TAKE ACTION IN RESPONSE)?							
la.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT I USE TO DETECT THE FAILURE?		;					
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WI IN-FLIGHT DETECTABILITY?	TH THE FMEA EVALUA	JATION OF YES X *NO					
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTI	EFFECTS OF THE FA NG ALTERHATE PROG	AILURE ! YES X NO					
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION PROGRAM LOGIC)?							
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE INDUCE ANOTHER FAILURE?	OVERSTRESS THE HAI	ARDWARE OR *YES NO X					
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE OTHER FUNCTIONS?	LOGIC, ADVERSELY	AFFECT *YES NO X					
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHAN	TOLERATE (CONSID GE TO FMEA CRITICA	DER CREW . *0 X *1 2 2					
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILU TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRE	RE MODE, ARE CUES D CORRECTIVE ACTIO	PROVIDED N/A YESX NO ON?					
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:							
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?		YES X ≯IIO					
*EYD:	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/ ANATION REQUIRED (SEE BELCH)	/EHICLE?	YES MOX					
	SE/RETENTION PATIONALE SUMMARI							
] NO H/S ISSUES 3. ☐ NO SOFTWARE D HARDWARE ACCEPTS RISK 4. ☐ DETECTION DUR		5. ☐ ACCEPTANCE RATIONALE BELOW6. ☐ RECOMMENDED CHANGES BELOW					
—								
	FMEA CHANGE RECOMMENDED							
- .								
EXPLANATION/COMMENTS:								
- · · · · · · · · · · · · · · · · · · ·								
 The GN&C RM Program will automatically deselect a failed jet and issue an alert. Detectable in thrust chamber but not in nozzle. 								
6. This is a criticality I failure and cannot be tolerated.								
7.	The thrust chamber pressures can be downlin	ked.						
8B. Same as primary.								
	[· · ···· 🗸 •		•					

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

	:FWD - REACTI :THRUSTER ASS		FMEA N		-13131		REV:	
	:MC467-0029						ի\Մ։	-
.P/N VENDOR			MISSIO	NS: HF	VF X			
.QUANTITY				S): PL				
	ONE REQ'D PE	R SIDE	NUMB ER					
	: (DOWN FIRING		AFTER		=		-CIP ECTAIN	2
•	TIDORIA I TICTICO		R EDUNDANC'				h: / n	
• S/TIMES DO	ETECTABLE IN F			1 SUNLER		TO EFF		C-N/A
*LWIFOUF DE	FIFCIABLE THE	LIGHT: F 1E3			SECON	=	261+	
MINIOS I SAL	KAGE OR	TNETDIENT	CATIONS			_	NDC LOSSEA	. T C +
*WINGV FEWS	NAGE UK	TMCTPICMI	FAILURE)CCUMEA	113.
• A B OHNER TOUR	ti ha ha a timba hima m	vec				-0001-		
	RNAKCUND?	********				SH-010		
.VISUAL EXA	AMINATIUN				VS 70-	421001	L	
•								
• `								
•								
•	PREPARED				PROVED	SY:		
•	DE S	J	TAGGART		DES			
•	REL	-	R DIEHL		REL			
•		-						
•				,				
.ITEM: THRE	USTER, VERNIER							
1 EN 157	7159).							

- 1 CN 13//1381.
- .FUNCTION:
- TO PROVIDE THRUST FOR LOW LEVEL ACCELERATIONS ASSOCIATED WITH POINTING MANEUVERS AND THREE AXIS ATTITUDE HOLD. THRUSTER FIRES IN +2 DIRECTION FOR + PITCH AND -Z ACCELERATION. INCLUDES INLET VALVE, INJECTOR, THRUST CHAMBER, NOZZLE EXTENSION, HEATER, INSULATION, PRESS/TEMP X SOUCERS.
- .FAILURE MODE: OVERHEAT/BURNTHROUGH (F)
- .CAUSE(S):
- MAX PRESSURE SPIKES, SURFACE DEFECTS IN THE PROTECTIVE DISILICIDE COATING FOR CHAMBER WALL AND VIERATION.
- .EFFECT(S): CN (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF VERNIER THRUSTER. (B) POTENTIAL DAMAGE. (C) FOTENTIAL
- EARLY MISSION TERMINATION. (D) POTENTIAL LOSS OF VEHICLE. CRITICAL DAMAGE COULD OCCUR BEFORE FAILURE IS DETECTED.
- .CURRECTING ACTION:
- ISOLATE FAILED THRUSTER AND USE OTHER THRUSTERS.
- .REMARKS/HAZARDS:
- PUTENTIAL HAZARD FROM ESCAPING HOT GASES IN THE MODULE AND POTENTIAL PROPAGATION OF FAILURE IF NOT ISCLATED IN A TIMELY MANNER.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

FMEA NO 03-2F -131310-4 REV: 12/08/78 SUBSYSTEM : FWD - REACTION CONTROL

.ASSEMBLY :THRUSTER ASSY ABORT:

CRIT. FUNC: 1

.P/N RI :MC467-0029 CRIT. HDW: 1

.P/N VENDOR: .QUANTITY :2 MISSIONS: HF VF X FF OF SM PHASE(S): PL LO 00 X DO LS

:ONE REQID PER SIDE

: (DOWN FIRING)

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

.PREPARED BY:

APPROVED/BY: MONU APPROVED BY

.DES .REL

DES J TAGGART R DIEHL REL

SSM REMO

Mark Drull APPROVED WITH CHANGES

See Section 13.0

.ITEM: THRUSTER, VERNIER

(EN 157/158).

. FUNCTION:

TO PROVIDE THRUST FOR LOW LEVEL ACCELERATIONS ASSOCIATED WITH POINTING THRUSTER FIRES IN +Z DIRECTION MANEUVERS AND THREE AXIS ATTITUDE HOLD. FOR + PITCH AND -Z ACCELERATION. INCLUDES INLET VALVE, INJECTOR, THRUST CHAMBER, NOZZLE EXTENSION, HEATER, INSULATION, PRESS/TEMP XSDUCERS.

.FAILURE MODE: OVERHEAT/BURNTHROUGH (F)

.CAUSE(S):

- MAX PRESSURE SPIKES, SURFACE DEFECTS IN THE PROTECTIVE DISILICIDE COATING FOR CHAMBER WALL AND VIBRATION.
- .EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF VERNIER THRUSTER. (B) POTENTIAL DAMAGE. (C) POTENTIAL EARLY MISSION TERMINATION. (D) POTENTIAL LOSS OF VEHICLE. CRITICAL DAMAGE COULD OCCUR BEFORE FAILURE IS DETECTED.
- (A) INTERMETALIC DIFFUSSION LAYER FORMS AN INTEGRAL BOND BETWEEN THE DISILICIDE COATING AND THE PARENT COLUMBIUM MATERIAL (C-103) AND TENDS TO RESIST SHOCK LOADING. (B) PRIOR TESTS CONDUCTED ON THE R1-1 THRUSTER HAVE DEMONSTRATED THE ABILITY OF THE DISILICIDE COATING TO LITHSTAND IMPACT LEVELS AND THERMAL STRESSES PRODUCED BY TEMPERATURES IN EXCESS OF 2900 DEGREES F. TORCH TESTS HAVE DEMONSTRATED THE INSENSITIVITY OF THE R512A COATING TO THERMAL SHOCK. (C) AUDIT CONDUCTED 9-2-76 VERIFIED THAT THE SUPPLIER INSPECTION CONTROLS RAW MATIL, IDENTIFICATION OF PARTS MFG. PROCESSES, CORROSION PROTECTION, CONTAMINATION CONTROL, AND

.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:

FLOURESCENT PENETRANT INSPECTION PRIOR TO COATING TO DETECT SURFACE FLAWS AND X-RAY INSPECTION IS REQUIRED FOR DETECTION OF INTERNAL CDATING THICKNESS AND QUALITY IS CONTROLLED BY MPS 525 WHICH DEFECTS. WILL REQUIRE CERTIFICATION THAT COATING PROCESS CONFORMS TO THE PROCESS SPECIFICATION, VISUAL INSPECTION, VERIFICATION OF COATING THICKNESS &

TEST TO VERIFY COATING INTEGRITY. TURNAROUND INSPECTION TO INCLUDE VISUAL INSPECTION FOR EVIDENCE OF BURN THROUGH AND WHERE ACCESSIBLE.

USE OF FIBER OPTICS NDE TO INSPECT FOR SURFACE FLAWS.

(0) NO FLIGHT FAILURE HISTORY.

Meeting Minutes

Review of JSC 14651, Hardware/Software Interaction Analysis Volume VIII, Forward Reaction Control System Part 1 of 2.

1. Meeting held at Rockwell International, Downey, 1:00PM to 2:30PM, 9/24/79.

2.	Attendees	<u>Organization</u>		Phone
	Edward Vonusa	NASA		X-1470
	Dave Latham	JSC Reliability (Boeing)		527 - 0323 FTS
	Rudy Kubica Larry Gladu Bill Meyers Bob Diehl	RI Propulsion/RCS RI System Engineering RI System Engineering RI Reliability	•	X-4720 X-1189 X-1726 X-2098

3. The following changes were discussed and will be incorporated in the final release of Forward Reaction Control System Hardware/Software Interaction Analysis and will be reflected in next update of Fwd RCS FMEA:

03-2F-101010-1: Change "SMU" to "SM". Insert "SM Alert" before "blue light."

03-2F-101013-1: Same as 03-2F-101010-1.

03-2F-101020-3: Same as 03-2F-101010-1.

03-2F-101020-4: Same as 03-2F-101010-1.

03-2F-101030-1: Add "X" in No. Block, question la.

03-2F-101030-2: Add V42P1116C to Explanation 1. and 2.

03-2F-101060-1: Show class 3 alarm with blue light and class 2 alarm with red

light. Add V421116C. (Explanation 1.)

03-2F-101060-2: Add "X", No Block, question la.

03-2F-101060-3: Same as 03-2F-101060-1.

03-2F-101060-4: Same as 03-2F-101060-1.

03-2F-101060-5: Same as 03-2F-101060-1.

03-2F-101070-1: Under 1 & 2 Explanation, add V421113C, 1114C. Change class

2 to 3.

03-2F-101080-1: Change FMEA to show detectability method.

03-2F-101090-1: Under 1 & 2 Explanation, change V42P1110C, 1112C to 1113C,

1114C. Change class 2 to 3. Add gross leakage detectability

(see 03-2F-101080-1).

- O3-2F-101095-2: Change "X" from Yes Block to No Block, question1. Under Explanation, delete 1 & 2 (failure is one leg only requires failure of both legs to actuate C & W).
- Under 1 Explanation, add gross leakage detectability (see 03-2F-101080-1). Under 7 Explanation and FMEA change add V42P1115C. Change FMEA to show detectability.
- <u>03-2F-102108-1</u>: Under 1 Explanation, add gross leakage detectability (see 03-2F-101080-1) Under 7 Explanation add V42P1115C.
- 03-2F-102120-1: Under 1 Explanation, add oxidizer measurement numbers, and add "failed off thruster will give "failed jet on C & W".
- 03-2F-102150-1: Same as 03-2F-102120-1 plus retain V42P1312C and delete 1313C and 1314C.
- <u>03-2F-102170-1</u>: Under 1 Explanation, add measurements V42X1333X, 1233X. Change class 2 to 3.
- Under 1 Explanation, add V42P1210C, 1212C, 1216C and add to to FMEA detectability. Add X in FMEA change recommended block.
- 03-2F-111110-2: Same as 03-2F-111110-1.
- 03-2F-111110-3: Under 1 Explanation, add gross leakage detectability (see 03-2F-101080-1)
- O3-2F-11111-4: Change X from No Block to Yes block for question 1. Under Explanation, delete 1st paragraph and 1. (White Sands Test on vernier showed complete loss chamber pressure which is detectable. Similar gas bubbles in propellant tests are planned for primary thrusters).
- 03-2F-121308-1: Under 1 Explanation, the class 3 alarm is doubtful. Check and verify findings with Bill Meyers RI Systems Engineering. Also add gross leakage detectability (see 03-2F-101080-1).
- 03-2F-121311-1: Change Failure Mode to agree with failure mode in FMEA.
- 03-2F-121312-1: Under 1 Explanation, add "If failure is upstream of throat it will be detected by PC; if failure is downstream of throat it will not be detected."
- 03-2F-121313-1: Change X from Yes Block to No Block, question 1. Delete 1. under Explanation (failure is downstream of throat and will not be detected by PC).
- O3-2F-131310-3: Change X from Yes Block to No Block, question 1. Add X to FMEA change recommended block. Under 1. Explanation, delete entire sentence (the pressure transducers are snubbed by an orifice and will not detect the erratic operation). Change FMEA to indicate no detectability.

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JSC Reliability (Boeing)

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Title: HARDWARE/SOFTWARE INTERACTION ANALYSIS

Volume VIII, Forward Reaction Control System, Part 1 of 2

Prepared by: NB - Reliability Division

Distributed by: NB - SR&QA Data Center

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